Expert Views

European Windstorm Risk in a Warming World

Part Three of a Five-Part Knowledge Series

SCOR
The Art & Science of Risk

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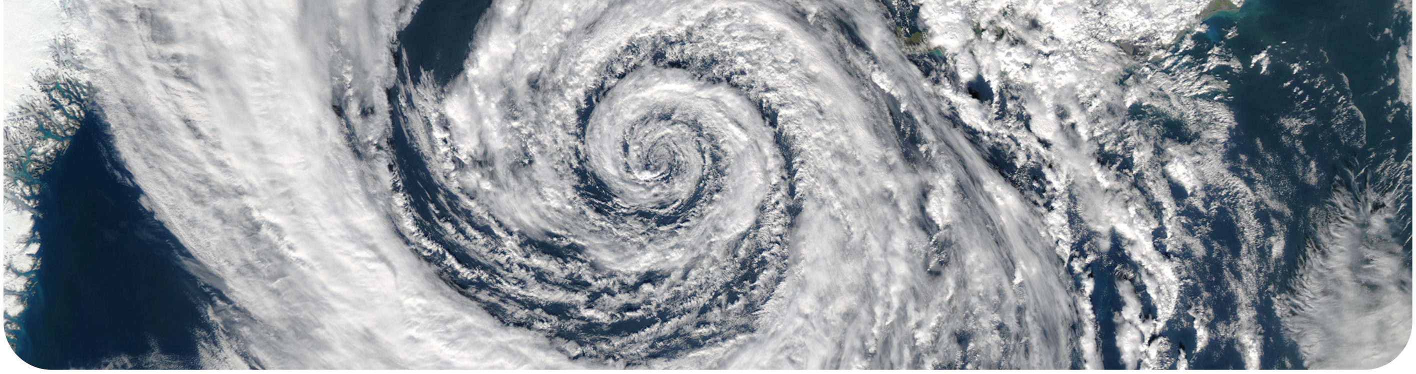


Introduction to European Extratropical Cyclones

The Sleeping Giant

Since 1990, European windstorms, otherwise known as European extratropical cyclones, have accounted for around EUR 100 billion in insured industry losses, representing approximately 30% of the total insured industry losses in the EMEA region — the two other main loss drivers being convective storms and floods (Figure 1a and Figure 1b). In recent years, the adverse loss experience from European floods and convective storms has illustrated how a warming climate, rapidly growing exposures and inflation are converging in the form of outsized losses, challenging our assessment of these natural catastrophes.

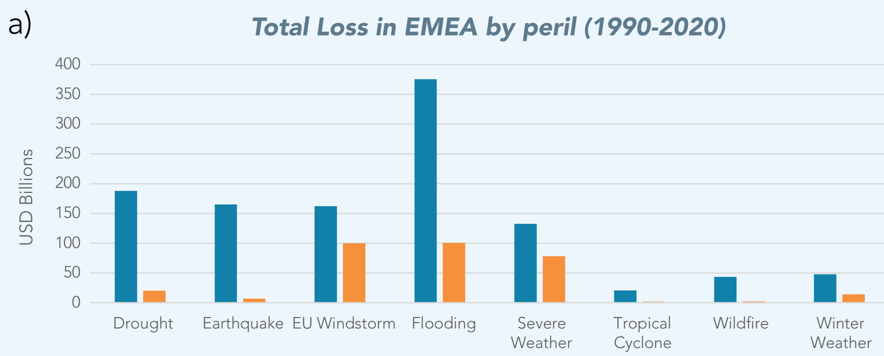
In contrast, European windstorms have had a relatively benign run over the past two decades, with no market-turning event to trigger a fundamental review of how we assess the risk associated with them.

European windstorm risk is a sleeping giant. As an industry, therefore, it is imperative that we evaluate how emerging signals from changes in climate, inflation, exposure and building stock are influencing loss costs for this peak peril.

This publication is the third part in our Climate Change Knowledge Series. It outlines recent findings in terms of quantifying the potential future impact of physical climate change on European windstorm loss costs, over a five- to ten-year time horizon.

Figure 1.

a)



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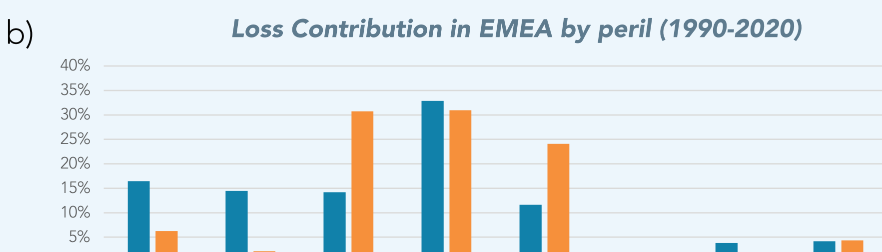


	Drought	Earthquake	EU Windstorm	Flooding	Severe Weather	Tropical Cyclone	Wildfire	Winter Weather
■ Economic	16%	14%	14%	33%	12%	2%	4%	4%
■ Insured	6%	2%	31%	31%	24%	1%	1%	4%

■ Economic ■ Insured

Source: Aon Catastrophe Insight 2021.

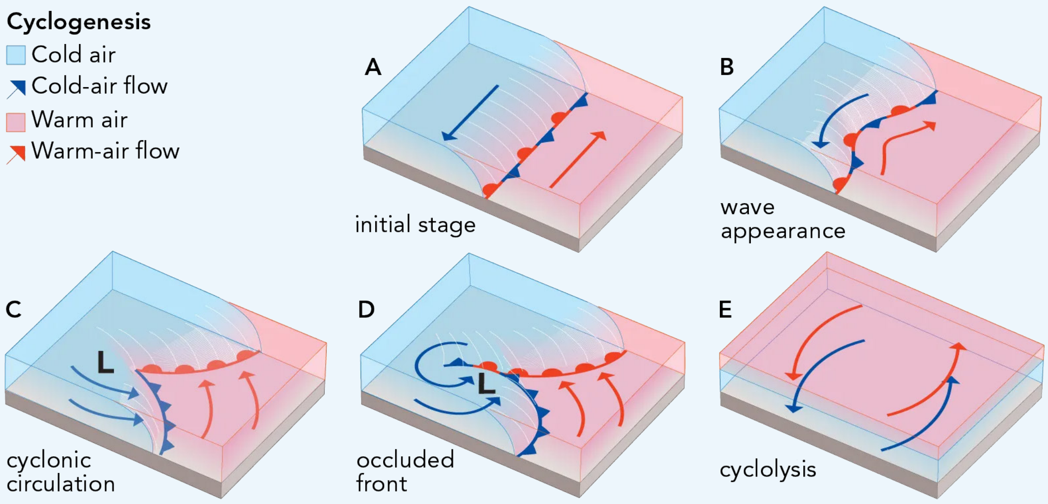
Characteristics of the Peril

Extratropical Cyclones (ETCs) are large-scale low-pressure systems, usually spanning between several hundred and more than 1,000 km and occurring in both hemispheres between 30° and 60° from the equator. These cyclonic structures can produce strong winds and are generally associated with rainfall events. They are one of the most prominent atmospheric processes in the mid and high latitudes and play an important role in the hydrological cycle. They typically occur between October and March in Europe. Since wind is the main damaging mechanism of ETCs, they are popularly known as windstorms, however they can also generate significant flood losses. Maximum wind speeds can reach 140 to 200 km per hour and, in extreme cases, up to 250 km per hour in exposed coastal locations (Barredo 2010).

The main mechanism behind ETC genesis is the differential heating of the Earth's surface. Due to the Earth’s curvature, equatorial regions receive more heat from the sun than polar regions. This generates an equator-to-pole temperature gradient and leads to a density difference between air masses (referred to as baroclinicity). This temperature gradient creates a difference in air pressure that can trigger the motion required for the development of an ETC. ETCs have a rotating character, a process often referred to as cyclogenesis (Figure 2). ETCs usually have cold and warm fronts separating the cold and warm air masses, and are steered from west to east by large-scale winds (westerlies) across both the Northern and Southern Hemisphere.

While the maximum wind speeds of ETCs are on average less than those of tropical cyclones, their size and duration over land covers a wider footprint that can lead to the accumulation of many smaller claims. Their losses stem mainly from wind damage to buildings, infrastructure, automobiles and forestry, and are typically driven by peak wind gusts (Prahl, et al. 2012). The combination of strong winds and low pressures can also lead to coastal flooding by the so-called storm surge phenomenon. In areas such as the southeastern coastline of the UK, storm surge is a much larger loss driver compared to elsewhere on the European coast. ETCs rarely generate large losses from inland river or surface flooding. Inland flooding can occur on fast responding catchments prone to flash flood events, or when a series of ETCs occur within a short time frame.

Figure 2. Evolution of an extratropical cyclone from its initial phase to its dissipation. "L" refers to a low-pressure system.



Source: Encyclopaedia Britannica.

Past Trends and Natural Variability

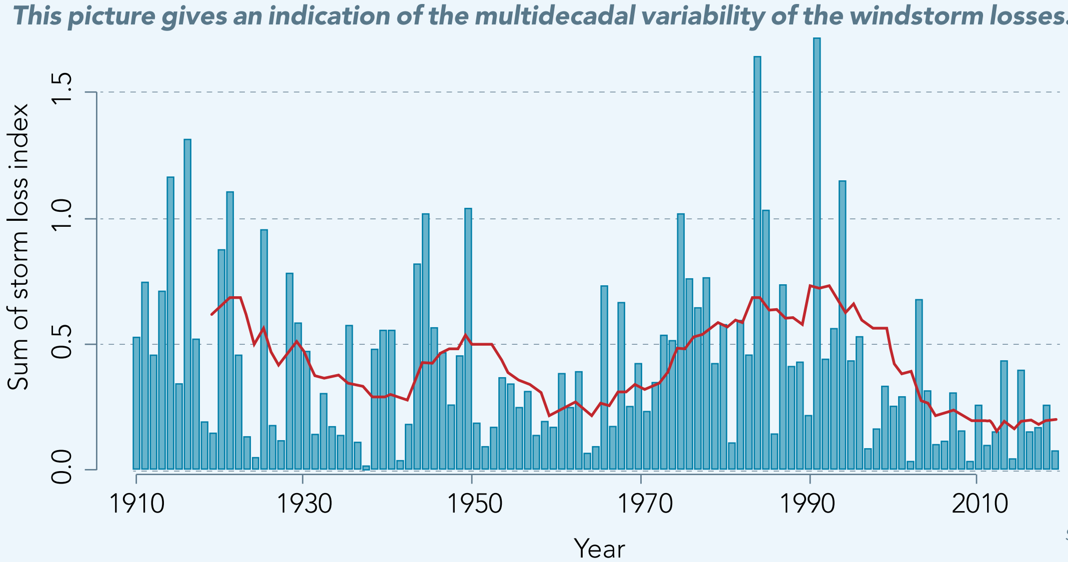
The location, frequency and severity of ETCs are heavily influenced by natural climate variability – thus making it difficult to tease out potential human-induced signals from background noise. In particular, the North Atlantic Oscillation (NAO), which represents the fluctuation between the Icelandic low pressure system and the Azores high pressure system, influences the location of storm tracks across the North Atlantic. Positive phases of the winter NAO are associated with more frequent westerly winds over Northwestern Europe and more settled weather in Southern Europe, and vice-versa during negative phases. Therefore, to understand and try to isolate the impact of anthropogenic climate change on ETCs, it is first necessary to quantify the observed long-term variability from climate modes such as NAO. Feser et al. (2015) collected an extensive number of studies looking at the long-term trends of European storm activity to try to see if an increasing or a decreasing trend could be found for European windstorms. This work highlighted the fact that no clear consensus exists among these studies, and that the detection of a trend strongly depends on the type of data used and the time period considered.

Indeed, when looking over the past 50 years of storm activity, rather than a trend, what we see is fluctuating behaviour at annual to multi-decadal scales over specific regions in Europe. The scientific consensus indicates that in the north-western parts of Europe, an active and stormy period began in the 1970s, which reached a century-peak in the 1980s to early 1990s and has significantly decreased since then. The outlook for European windstorm activity seems to show a slight upward trend, but with high uncertainty (Cusack 2020). This multi-decadal behaviour is nicely illustrated for the Netherlands in Figure 3 (Cusack 2013).

The low signal relative to background noise is a finding mirrored in the IPCC's Sixth Assessment Report on "Weather and Climate Extreme Events in a Changing Climate". In particular, the report notes, "there is low confidence in past-century trends in the number and intensity of the strongest ETCs due to the large interannual and decadal variability and due to temporal and spatial heterogeneities in the number and type of assimilated data in reanalyses, particularly before the satellite era." (Seneviratne, et al. 2021).

Figure 3. Histogram of values representing the sum of storm loss index each year, and the corresponding running 10-year mean (red line) for the Netherlands.

This picture gives an indication of the multidecadal variability of the windstorm losses.



Source: Cusack 2013.

The impact of climate change on European windstorms

Literature review

We conducted an extensive review of the scientific literature and found that the global atmospheric processes driving ETC storm activity over Europe are expected to react to global warming, but in various and sometimes competing ways (Catto, et al. 2019). The consequential net impact on wind and flood losses over the next decade is therefore fraught with uncertainty.

As a result of these competing effects, ensemble climate model experiments project a large spread in European storm activity over the coming decades.

Recent studies assessing the mean response identify some weak emerging signals (Zappa and Shepherd 2017). In particular, a tripolar pattern can be observed over Europe, with a slight increase in storm frequency and intensity over the north of Central Europe and the British Isles, and a decrease over the higher latitudes and the Mediterranean basin. This signal is weak, detectable only when looking at the 2070-2100 horizon. These studies were based on the CMIP5[1] models. The newly available CMIP6 models have better resolution, which may improve our understanding of the physical processes at play.

Regarding changes in precipitation driven by ETCs, there is relatively high confidence that there will be a future increase, characterized by strong regional variability (Zhang and Colle 2018). If this happens, some regions may see material increases in inland flood severity. In addition, coastal flooding is likely to increase due to more severe storm surge events driven by sea level rises (Catto, et al. 2019). In summary, relative to observed inter-decadal variability in ETC activity over recent decades, the impact of climate change on ETC event frequency is small. However, we observe a growing body of evidence to support an increasing trend in flood severity (and hence loss) associated with ETCs.

1. Coupled Model Intercomparison Project – Phase 5

Scenario Design and Implementation

Our framework assesses the near-future potential impact of climate change on (re)insured losses, with the aim of informing the pricing and steering of underwriting portfolios. Based on the scientific literature review, three scenarios were designed to quantify the impact of credible climate signals. The scenarios were applied to a common modelling baseline for all clients over a five- to ten-year time horizon, balancing business steering needs (one to three years) with the outputs from climate models producing multi-decade forecasts. For more details regarding the assumptions used and technical implementation, please refer to the first part of this Knowledge Series (Seria and Herboch 2021).

Three scenarios were chosen to better understand how specific climate change signals could impact our European windstorm portfolio (see also Table 1):

1. **Increased Storminess:** this scenario computes the loss impact of an increase in storm intensity over the north of Central Europe;
2. **See Level Rise:** this scenario computes the loss impact arising from a 2 cm increase in sea levels in the Southeast of the UK;
3. **Climate Variability Benchmark:** this scenario computes the loss impact of using a European Windstorm model calibrated on a 25-year history (1989-2013) rather than a 42-year history (1972-2013). It serves as a benchmark against which to compare loss impacts from the climate change scenarios above.

While these scenarios consider changes in wind and storm surge losses, the related change in inland flood risk will be considered in a later publication exploring the physical impact of climate change on flood hazard, and hence loss.

For each scenario, a climate-conditioned catalogue was created from the underlying vendor model. Because there is limited flexibility to modify the hazard data in cat vendor models, approximations were applied to assess the relationship between hazard changes and loss changes.

Table 1. Overview of the three scenarios implemented to assess the potential impact of climate change on European ETC risk.

Peril Characteristic	Climate Change Signal	Scenario Description [projected from model baseline to 2025-2030]
Storminess (Storm Frequency / Severity)	Competing signals Net balance not clear	**Increased storminess** • +0.6% wind speed & storm frequency over Central EU in the next decade
Storm Surge (due to sea level rise)	Strong signal Increase	**Sea Level Rise** • +2 cm increase in sea level
Climate Variability Benchmark	Not applicable	**Climate Variability Benchmark** • Model calibrated on a 25-year history (1989-2013) rather than a 42-year history (1972-2013)

Devastated forest afer Kyrill - January 2007

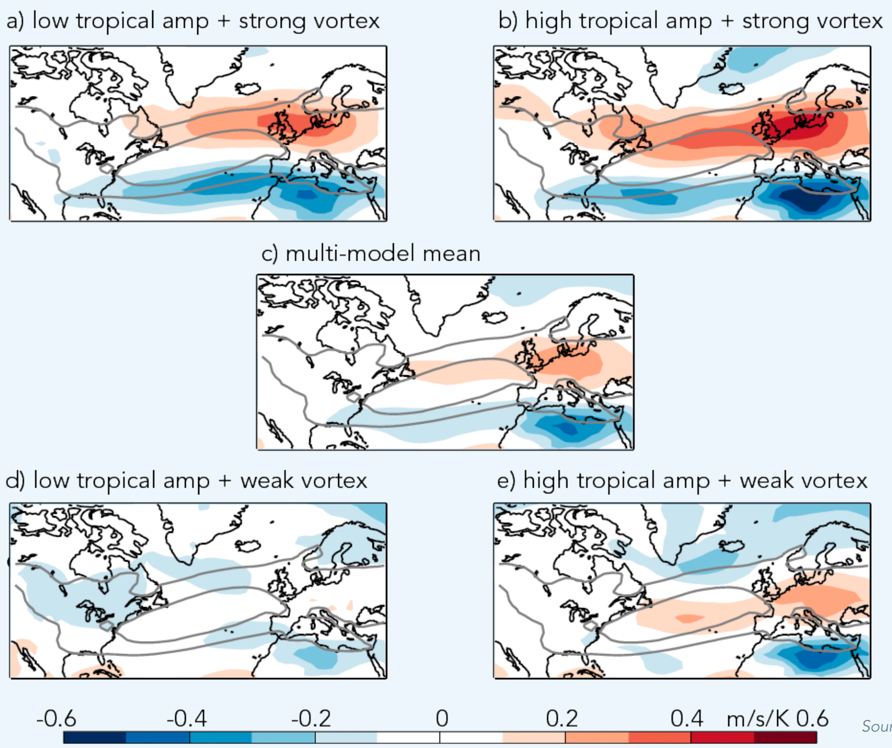
Increased Storminess

As mentioned earlier, atmospheric processes driving storminess over Europe are projected to react to global warming in various ways. The net impact of these processes remains unclear. Figure 4 taken from Zappa and Shepherd (2017) illustrates this very well. It shows the implied change in wind speed over the North Atlantic basin for four different plausible scenarios defined by the tropical amplification[2] and stratospheric vortex[3] responses.

The high tropical amplification and strong stratospheric vortex conditions (Figure 4b) induce the strongest increase in wind speed over Central Europe, together with a slight decrease in wind speed over the Northern Atlantic and a strong decrease over the Southern Mediterranean basin. This "increased storminess scenario" was selected as it leads to relatively higher increases in wind speed over Central Europe. It implies an increase of around +0.6% in windstorm intensity and frequency over Central Europe for the time horizon 2025 to 2030, relative to a baseline of 2020. The scenario was implemented via the following steps:

1. Identifying stochastic events over Central Europe to be adjusted;
2. Translating forecasted windstorm intensity changes into a change in mean damage ratio;
3. Defining frequency and severity adjustments to reflect the target change in mean damage ratios;
4. Implementing event-specific adjustments to the baseline modelling results across clients.

Figure 4. Wind speed anomalies per degree of global warming according to four plausible scenarios of climate change that are conditioned on the tropical amplification and stratospheric vortex responses, (c) representing the multi-model mean.



Source: Zappa and Shepherd 2017

2. Tropical amplification: enhanced warming in the tropical upper troposphere (10 to 12 km above sea level).
3. Stratospheric vortex: westerly winds over the Arctic between 10 and 50 km above sea level.


Coastal erosion of the cliffs at Skipsea, Yorkshire

Sea Level Rise

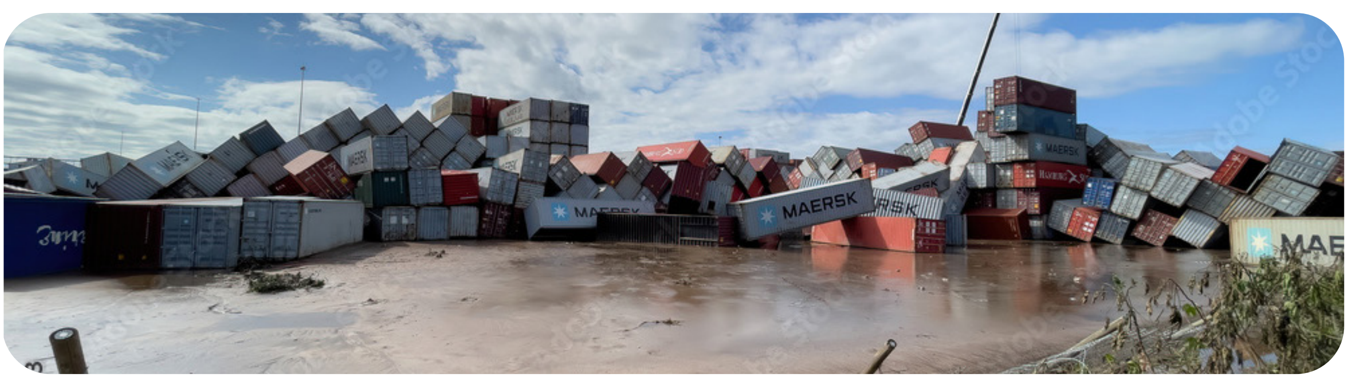
Sea level rise can increase the frequency and severity of storm surge events. This study focuses on the area of Europe particularly prone to storm surge, the southeastern coast of the UK, which is an area covered by the main modelling vendors.
The modelled impact of sea level rise on the European windstorm portfolio was based on analysis from the UK Prudential Regulatory Authority (PRA) as part of the 2019 general insurance stress test study (RMS 2019). This study assumes a total sea level increase of 2 cm corresponding to an annual increase in sea levels for the UK of approximately 3 mm per year, projected over a seven-year period. This empirical annual trend is in line with studies reviewed (Jenkins, Perry and Prior 2008) and an internal trend analysis of sea level data from a sample of UK sites. We chose to leverage the PRA study due to its pre-computed loss impacts for the assumed sea level increases[4]. The magnitude of sea level rise assumed depends on the vintage of sea level data in the model. In our case, the models are adjusted to reflect current climate, hence a 2 cm increase is appropriate for a five- to ten-year time horizon. However, if the baseline of the unadjusted model is older, it may be prudent to use a weighting of the PRA's 2 cm scenario and the 10 cm scenario, based on the accumulated sea level rise over the period between the vintage of the model and the forecast point. In discussion with market participants, few modellers apply this adjustment, yet it is one of the most sensitive assumptions.

Climate Variability Benchmark

The climate variability benchmark is not intended as a climate change scenario per se. It serves as a basis against which to compare the loss impacts of the two other ETC scenarios. It estimates the change in European windstorm loss due to a change in the time horizon considered for loss calibration.

This scenario is based on the climate variability view of RMS, which is obtained by calibrating the RMS European windstorm model using a 25-year period (1989 to 2013), which is shorter than the reference view based on 42 years (1972 to 2013). This shorter time horizon causes an increase in losses in some areas and a decrease in others, depending mainly on whether the largest events happened before or after 1989. Again here, one could use alternative time horizons to illustrate decadal loss variability. However, within the timeframes of the climate change study, the effort required to recalibrate the model on, say, losses that only occurred in the 1990s, did not seem justified relative to the gains to be made from investigating additional climate-sensitive perils.

The benchmark scenario losses were computed by remapping client event losses from the reference catalogue (based on 42 years) to an alternative catalogue (based on 25 years).



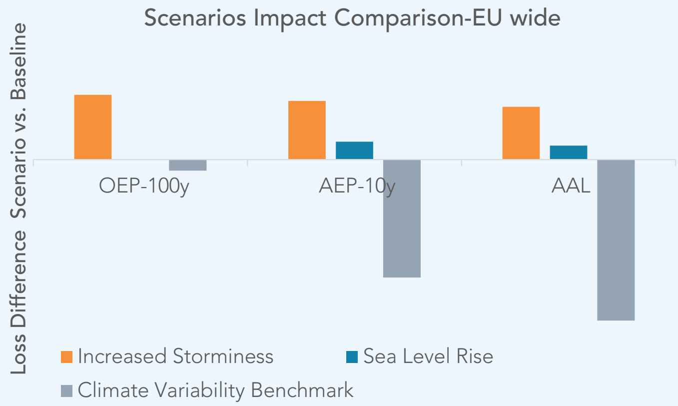
4. RMS derived loss changes by running the UK industry exposure database through the European windstorm model. As we understand, coastal storm surge depths were increased to match the desired mean sea level increase, considering changes in the probability of breach/overtopping of coastal flood defences, as well as an increase in surge propagation.

Results and Insights

Figure 5 shows the loss impact of the three scenarios described above for a Europe-wide representative insured portfolio over a five- to ten-year time horizon. The following insights emerge:

1. Over the near-term, the climate variability benchmark results illustrate that decadal loss variability ranks highest as the driver of loss change, with a mean loss reduction of more than 10% when calibrating models over 25 years rather than 42 years. Similarly, calibrating a model based on the loss experience in the 1990s relative to the past two decades would result in significantly higher losses. In contrast, storminess and sea level scenarios mean loss impacts were each less than 5%.
2. The storminess scenario loss changes are higher than for the sea level rise scenario. Firstly, this is because losses are more sensitive to changes in wind hazard than for any sub-peril. In this case, a 0.6% increase in storminess generated a loss change of 3 to 5% across the distribution. Secondly, the relative ranking is in part due to the relatively small 2 cm sea level rise assumed. In contrast, for tropical cyclones in the US, we observe much larger increases in sea level, hence larger (economic) storm surge loss impacts per unit exposure. UK-concentrated portfolios would experience higher loss impacts for the sea level rise assumed here. Lastly, older vintage models would require larger sea level increases when projecting to the period 2025 to 2030, resulting in larger loss increases.
3. Across all scenarios, loss distributions experience larger shifts at shorter return periods than in the tail. This pattern is observed across almost all of the twenty scenarios in SCOR's climate change study. The expectation then is that attachment probabilities (and hence loss costing) for catastrophe excess of loss (CatXL) treaties will increase more for lower "working" layers than for top CatXL layers. Similarly, we expect bigger increases for proportional and aggregate programs than for CatXLs generally – an expectation confirmed by recent losses for climate-sensitive perils across the world. Climate scenario analyses, therefore, can help reinsurance buyers to assess how climate signals could influence near-future costing, informing the setting of retention levels and rates to ensure sustainable returns for both clients and reinsurers.

Figure 5. Impact on OEP-100y[5], AEP-10y[6] and AAL[7] of the Increased Storminess scenario (orange), the Sea Level Rise scenario (blue) and the Climate Variability Benchmark scenario (grey) for a Europe-wide representative portfolio. The financial perspective is gross loss, after policy but before reinsurance terms and conditions.



5. 100-year return period loss on an OEP (occurrence exceedance probability) basis
6. 10-year return period loss on an AEP (annual exceedance probability) basis
7. Average annual loss

Concluding Remarks

European windstorm risk is one of the largest drivers of catastrophe reinsurance in Europe. The impact of global warming on the behaviour of this peril remains a critical topic for academia, (re)insurers and risk managers. At SCOR, we have designed and implemented scenarios (Table 1) to quantify the near-term impact of plausible climate signals, helping clients to understand the potential impacts on their reinsurance purchase and supporting underwriting portfolio steering. The scenario analysis illustrates that over a five- to ten-year time horizon, two plausible climate signals generate minor loss impacts at a European scale relative to observed decadal loss variability.

While these scenarios have not prompted a fundamental rethink of European windstorm risk, they are useful as part of our wider catalogue of climate scenarios. Loss impacts are ranked across regions and perils globally, deepening our understanding of which signals are most loss-sensitive. In the face of adverse losses across several regions and perils in recent years, climate scenario analysis has aided the work of our actuaries, modellers and underwriters in terms of rebalancing SCOR's catastrophe portfolio, to reduce sensitivity to climate-sensitive perils and enable more sustainable portfolio earnings.

For now, European windstorm remains a sleeping giant. However, when the next market-turning windstorm event strikes, SCOR will be better positioned and better provisioned thanks to the efforts of our community of experts. We hope this study provides further motivation to embark on climate change studies, and we remain committed to supporting our clients on this journey.

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In this knowledge series, we suggest to read:

- Modelling Climate change for the (re)insurance industry
- Crop Insurance in India and Brazil: keeping abreast of a changing climate

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