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North Atlantic Hurricane Risk Variability in a Changing Climate

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Executive summary:

- Twelve Capital, through its cooperation with climate-tech firm reask, expects a modest increase in Atlantic hurricane risk over the forthcoming decades as a consequence of climate change. Cat Bonds and Private ILS coupons should however, compensate the investor, even after accounting for the increases in potential risk levels.
- Simulations of historical hurricane risk, using global climate model simulations, suggest that the observed heightened activity between 2000-2019 is more extreme compared to the mean of alternative simulated realities.
- Going forward, modelling results suggest that a "worst-case" style climate scenario of a continued rise in greenhouse gas concentration over the next century will likely increase North Atlantic hurricane activity over the period 2020-2060. Key patterns point to more dominant La Niña-type SST (Sea Surface Temperature) signals and a warmer tropical Atlantic.
- Under the same "worst-case" climate scenario, landfall risk is expected to increase by approximately 12% across the basin, with landfalls emanating from the Main Development and Gulf regions up by approximately 10%. Landfalls from the East Coast region are expected to increase by approximately 20%.
- Results show that the expected risk over the period 2020-2060 is likely to trend to a risk level similar to that observed between 2000-2019; the high activity observed over the last 20 years is predicted to be the future normal. This is an environment in which ILS securities have performed well.
- Climate variability will likely continue to drive US hurricane risk premia with increased demand for ILS capital to help the (re)insurance industry manage capital-intensive peak peril US Hurricane exposure.
- Climate change research allows Twelve Capital to improve understanding of the potential impact of climate variability on insured risk, helping to continuously enhance investment processes to build well-balanced Cat Bond and Private ILS portfolios.

Background

This research spotlight expands on the North Atlantic hurricane seasonal forecast methodology, produced by Twelve Capital and machine learning climate-tech firm reask, to assess the possible impacts of climate change on North Atlantic hurricane activity. Since June 2018, Twelve Capital and reask have worked closely together to develop hurricane forecasting tools using reask's proprietary machine learning algorithm.

Assessing climate change impacts on North Atlantic hurricane risk

The forecast methodology moves beyond traditional basin-wide hurricane activity metrics, such as hurricane count, towards a more complete insurance risk assessment framework that incorporates a measure of regional

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hurricane landfall risk. Risk metrics of storm activity and landfall probability are calculated explicitly for three risk regions; the Main Development Region (MDR), the East Coast Region and the Gulf Region (Figure 1).

Figure 1: Model region classifications. Source: reask and Twelve Capital.

Unlike the seasonal forecast, where actual observed climate data is used to forecast upcoming hurricane season activity, the method uses climate model output computed during the hurricane season based on simulations from the Community Earth System Model Large Ensemble ("CESM") climate model[1] to condition hurricane risk distributions.

The methodology combines the simulated climate model outputs with machine learning pattern recognition techniques to isolate relevant climate processes known to drive hurricane activity. The variability in hurricane risk is then assessed from (i) the variability in the climate state as captured by these drivers and (ii) the variability in hurricane risk given a certain state of the climate.

The methodology relies on a set of 40 different model simulations to ensure the uncertainty in the climate itself is being sampled.

The study is designed to quantify the variability of both historical and projected North Atlantic hurricane activity and landfall risk, focusing on trends between

1. The periods 1980-1999 and 2000-2019
2. The periods 1980-2019 and 2020-2060.

The approach aims to investigate three main questions:

1. How does the recent observed trend in hurricane risk compare to the modelled distribution of possible alternative historical scenarios?
2. How might the risk distributions shift under a projected warming climate?
3. What impacts could the outcome have on the pricing of Cat Bonds, Private ILS and on the management of portfolios?

How does the observed trend in hurricane risk compare to the broader distribution of possible simulated alternative historical scenarios?

The 40 different model runs are initially assessed over the periods 1980-1999 and 2000-2019. Observed hurricane activity shows that there has been a shift to increased risk levels during period 2000-2019 when compared to 1980-1999.

The observed historical metrics (HIST) in Table 1 show an increase in basin wide activity of approximately 50% with the expected number of landfalls increasing by approximately 12% for East Coast storms, 60% for MDR storms and 38% for storms emanating from the Gulf.

[1] CESM, Kay et al. 2015.

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The increased trend identified from the observed hurricane risk metrics can be interpreted as being representative of one single iteration of all possible realisations of the observation period 1980-2019. Different realties of the last 20 years could have been better or worse than what was actually observed.

The uncertainty in the actual observed climate can be assessed using 40 different possible alternative climates simulated using the CESM model. Sampling repeatedly from the simulated risk distribution for each of these 40 alternative climates, over the period 1980-2019, produces a picture of what risk expectations might look like for alternative realisations of the observed climate, shown as the CESM metrics in Table 1.

Table 1: Observed hurricane risk trends (HIST) and trends in simulated expected values from the CESM model (CESM). Numbers in brackets refer to the percentage change between the period 1980-1999 and 2000-2019. Source: reask.

		1980-1999		2000-2019	
Metric	**Region**	**CESM**	**HIST**	**CESM**	**HIST**
Count	North Atlantic Basin	12.4	10.2	13.2 (+6.5%)	15.3 (+50%)
	East Coast	4.5	3.5	4.8 (+6.7%)	5.6 (+60%)
	Main Development Region	4.7	4.2	5 (+6.4%)	6 (+43%)
	Gulf/West Caribbean	3.2	2.5	3.4 (+6.2%)	3.75 (+50%)
Landfalls	East Coast	0.9	0.85	0.96 (+6.7%)	0.95 (+11.8%)
	Main Development Region	0.95	0.75	1 (+5.3%)	1.2 (+60%)
	Gulf/West Caribbean	1.81	1.6	1.86 (+2.76%)	2.2 (+37.5%)

All metrics in Table 1 are trending upwards between the periods 1980-1999 and 2000-2019 with the observed shift in hurricane risk significantly more elevated than the expected shift simulated using the CESM model. Results suggest, assuming total reliance on the model, that the observed increase in both storm count and landfall risk over the periods 1980-1999 and 2000-2019 is on the more extreme side of the distribution of simulated outcomes. This is clearly shown in Figure 2, where the time series of the main Sea Surface Temperature (SST) based driver of activity is shown for both the CESM model runs (in grey, with mean in red)

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and the historical state as captured by ERA5[2] reanalysis (in green). The shift towards a more active state is sharper in the case of the historical state (green line) than would be expected from the mean of the CESM climate runs (red line).

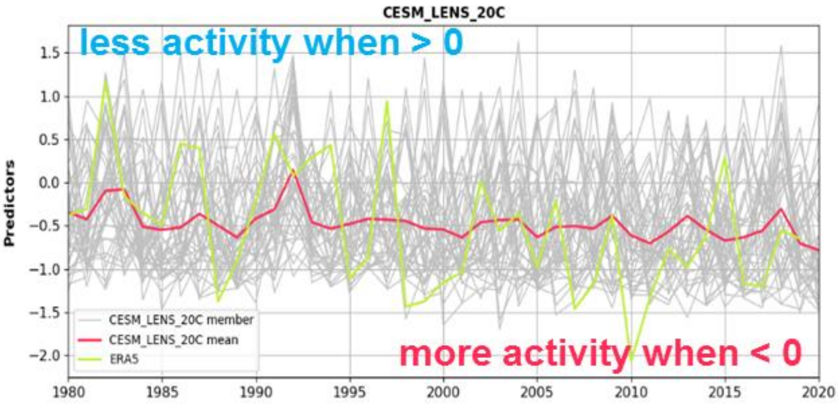

Figure 2: Comparison of CESM model output (grey lines with mean shown by the red line) and ERA5 reanalysis (green line) for the SST based driver of activity. Source: reask.

How might hurricane risk shift under a warming climate?

The simulated risk distributions over the periods 1980-1999 and 2000-2019 are projected to possible future climates using the CESM RCP8.5[3] scenario.

Table 2 shows the results of the expected modelled shift in hurricane risk incorporating the future climate scenario. The observed trend of increasing risk between the periods 1980-1999 and 2000-2019 across all risk metrics and regions is set to continue under a “worst-case” future climate regime.

Expected named storm activity is expected to increase by approximately 14% across the Atlantic basin, with the simulated risk distribution skewed towards higher risk levels (Figure 3). A key driver of this increase in risk is a consequence of the SST-based predictor in the model, driven by more dominant La Niña-type SST patterns with a warmer tropical Atlantic. Model runs are trending to more negative values of this SST based predictor, which correlates with more hurricane activity as shown in Figure 2.

Landfall risk is expected to increase across the basin by approximately 12% with the largest increase observed in the East Coast region (+20%). This marked increase in East Coast risk relative to the MDR and Gulf regions (approximately 10% for both regions) is attributed to changes in wind shear distribution along the East Coast of the US consistent with the recent findings in Ting et al. (2019) projecting a weakening of the natural protective barrier of wind shear along the US East Coast.

Interestingly the proportion of landfalling storms emanating from the MDR and Gulf regions is marginally decreasing but the overall number landfalls is increasing given the increase of the overall basin wide activity.

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[2] ERA5 is a dataset that provides hourly estimates of a large number of atmospheric, land and oceanic climate variables (https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5).
[3] The Representative Concentration Pathway (RCP) 8.5 corresponds to a future climate scenario where emissions continue to rise through the 21st century.

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Table 2: Expected risk for the 2020-2060 period relative to the changes in the period 1980-1999 and 2000-2019. Source: reask.

		1980-1999	2000-2019	2020-2060
Metric	**Region**	**CESM**	**CESM**	**RCP8.5**
Count	North Atlantic Basin	12.4	13.2 (+6.5%)	15 (+13.6%)
	East Coast	4.5	4.8 (+6.7%)	5.5 (+14.6%)
	Main Development Region	4.7	5 (+6.4%)	5.7 (+14%)
	Gulf/West Caribbean	3.2	3.4 (+6.2%)	3.8 (+11.8%)
Landfalls	East Coast	0.9	0.96 (+6.7%)	1.15 (+19.8%)
	Main Development Region	0.95	1 (+5.3%)	1.11 (+11%)
	Gulf/West Caribbean	1.81	1.86 (+2.76%)	2.01 (+8%)

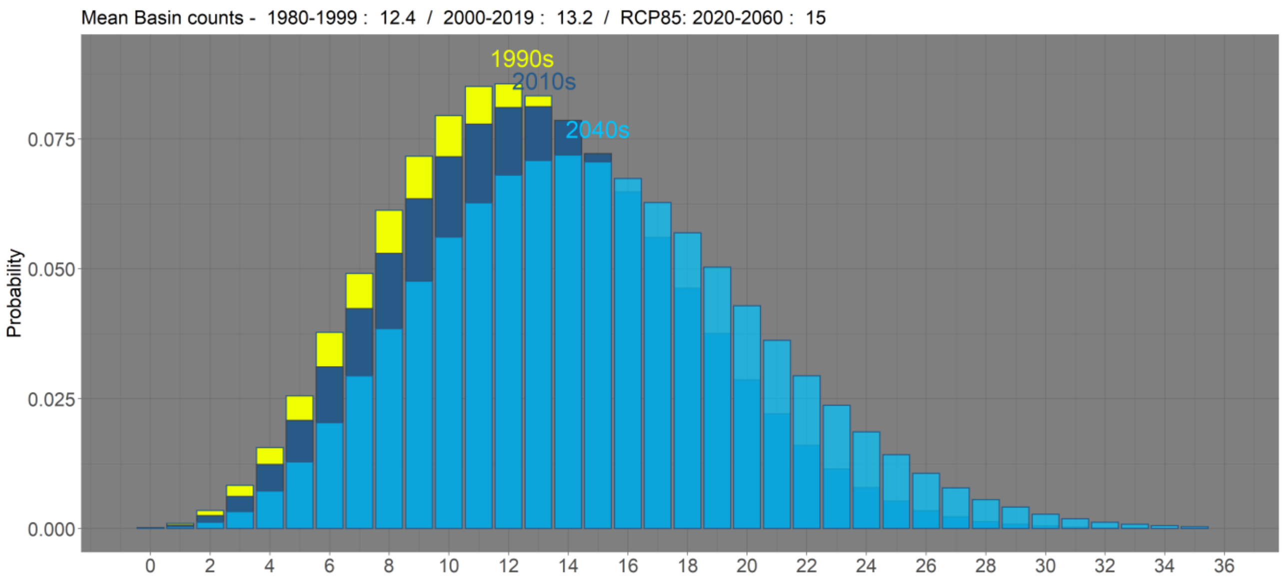

Figure 3: Basin wide activity for the 1980-1999 ("1990s"), 2000-2019 ("2010s") and 2020-2060 ("2040s") periods. All climate forcings come from the CESM ensemble runs. Source: reask.

Is the observed activity between 2000-2019 the future normal?

Comparison of the observed historical (HIST) values between 2000-2019 in Table 1 and the expected values simulated using the CESM model for the period 2020-2060 in Table 2 shows that, under the RCP8.5 scenario, hurricane activity is projected to trend to a risk level similar to that observed over the last 20 years.

How does all of this affect the pricing of ILS securities and the management of ILS portfolios?

Climate change is a slow and gradual process with time frames typically measured in decades. ILS securities, however, have much shorter maturity dates with Private ILS contracts typically expiring after 12 months and most Cat Bonds expiring not later than 36 months after pricing and issuance. The main factors driving hurricane risk (such as sea surface temperature) are well researched and are, to some extent, incorporated into the vendor models (typically AIR and RMS) used for the pricing of ILS securities. These models are frequently updated and as such aim to capture some of the changes in environmental conditions, e.g. the sea surface temperature. For that reason, the risk metrics used to price ILS instruments at the time of issuance reflect these gradual increases in the expected loss. ILS investors are therefore able to price in the current state of the climate into their investment decisions.

At the time of writing, the average expected loss in most Cat Bond portfolios stands at around 2.0-2.5% with spreads at around 600bps, thus corresponding to a risk-adjusted margin of around 3.5-4.0%. Even if all of the expected increase in landfall risk expected over the next decades (around 12%) was to be added on the expected loss on day one (i.e. today), the resulting margin above those increased risk levels would still make the ILS space an attractive fixed income asset class.

Whilst Twelve Capital believes that ILS pricing is sufficient from an asset class perspective, even under an adverse climate change scenario, a more in-depth analysis is needed on individual regions, cedents, trigger structures and with regards to portfolio construction. Incorporating continuous climate change research and development into Twelve Capital's investment process facilitates improved risk assessment over the medium term. Understanding both the uncertainty in the observed climate and the possible variability associated with potential future climates allows Twelve Capital to evaluate the risk levels associated with current and expected future trends. Twelve Capital's research and development forms a key part of its ESG framework and is a cornerstone of its approach to responsible insurance investing in a changing climate.

On a portfolio level a practical example is Twelve Capital's positioning during the 2020 hurricane season. As early indicators (correctly) pointed towards a high probability of a hyper-active Atlantic hurricane season, Twelve Capital implemented three levels of protection in its portfolios during the 2020 hurricane season:

1. An increase in cash balance to around 15%, from the usual 5-10%.
2. A reduction of risk in junior aggregate Cat Bond structures.
3. An overweight in index-linked structures and correspondingly an underweight in indemnity triggers

The portfolio measures implemented for this year's hurricane season are some examples of the many possibilities in Twelve Capital's dynamic portfolio construction process, which supports the construction of attractive ILS portfolios even in a world affected by climate change and other volatility-increasing topics.

Ultimately, Twelve Capital is convinced that ILS portfolios provide investors with access to a diversifying asset class that is well-positioned and robust enough to generate attractive returns, even after accounting for potential changes in climatological conditions.

References

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Ting, M., Kossin, J.P., Camargo, S.J. et al. Past and Future Hurricane Intensity Change along the U.S. East Coast. Sci Rep 9, 7795 (2019).

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Twelve Capital and reask – co-operation

Since June 2018, Twelve Capital and reask have worked closely together to further the development of hurricane forecasting tools by using machine learning. Both parties believe that advancements in technology and computing power can enhance ILS investment management.

reask is a catastrophe analytics specialist providing global solutions for tropical cyclone risk management and forecasting. reask is based in Sydney with its team of experts in risk analysis, machine learning and high performance computing. Their team has vast experience in natural catastrophe modelling having developed their expertise from previous engagements at RMS, Willis Re and other specialised firms.

Twelve Capital AG
Dufourstrasse 101
8008 Zurich, Switzerland
Phone: +41 (0)44 5000 120

Twelve Capital (UK) Ltd
Moss House, 15-16 Brook's Mews
London W1K 4DS, United Kingdom
Phone: +44 (0)203 856 6760

info@twelvecapital.com
www.twelvecapital.com

About Twelve Capital

Twelve Capital is an independent investment manager specialising in insurance investments for institutional clients. Its investment expertise covers the entire balance sheet, including Insurance Bonds, Insurance Private Debt, Catastrophe Bonds, Private Insurance-Linked Securities and Insurance Equity. It also composes portfolios of its Best Ideas. It was founded in October 2010 and is majority-owned by its employees. It has offices in Zurich and London.

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