ASSESSMENT OF EARLY FORECASTS OF THE ATLANTIC HURRICANE SEASON 2024



APRIL 2024



Executive Summary

- ➤ The climate and meteorological conditions are conducive to high hurricane activity in the 2024 season
- There is a bandwidth of projections when La Niña will happen and what the likely results may be
- Hurricanes are still random processes and a decent sized hurricane still has to hit a populated area to generate damage
- In heightened seasons, there is no clear signal in the data regarding tail events impacting Cat Bonds due to the random nature of events

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Hurricane formation overview

To understand hurricane risk, it is important to know how hurricanes work, and the key factors that can influence them. At a high level there are three main ones to consider:

- Sea Surface **Temperatures** Warm (WSST): Hurricanes are essentially large heat engines, meaning they get their energy from the heat in the water. In simplistic terms the warmer the sea water the more energy there is for (potential) hurricanes to utilise, influencing the number of hurricanes that are able to form in a season, the strength of the hurricanes, and where they are able to survive. Disproportionately warmer land masses also lead to stable high-pressure systems and influence the path of hurricanes.
- Vertical Wind Shear: These are winds in the middle-to-upper atmosphere that are able to "push over" hurricanes, i.e. inhibiting their formation. If the winds are lighter/stronger it can mean that more/fewer hurricanes can form, respectively.

 Steering Flows: These are the atmospheric conditions that direct where the hurricane travels, sometimes these can be such that hurricanes are pushed away from the US coastline, while at other times it means that hurricanes are able to more freely travel into the US.



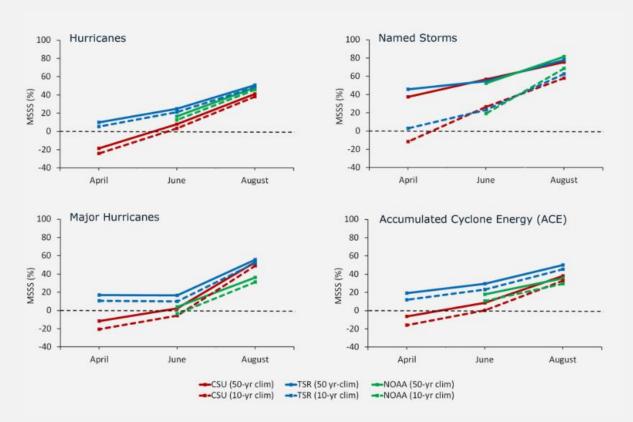
Climatological forecasts

In short, hurricane forecasting is very difficult. While the models (and the introduction of machine learning) are improving accuracy around seasonal forecasts, as well as hurricane path predictions, there is still a lot of uncertainty.

Traditionally, a number of agencies and universities release hurricane season forecasts in April, June, and then August, with accuracy tending to increase the later we proceed in the year. There are a number of meteorological and climatological factors that can influence the likely number of hurricanes that will form. The "signals" from these factors get clearer the closer one gets into the hurricane season, thus improving the accuracy of the predictions over time. The chart below shows past hurricane prediction accuracy from a number of actors.



Figure 1: Past hurricane prediction accuracy



Source: https://seasonalhurricanepredictions.bsc.es/background-information/skill. As at 14 March 2024.

Mean Squared Skill Scores (MSSS) for three different forecast agencies for a 50-year climatology mean (1951-2000) and for the previous 10-year mean. Note the improvement in the skill as the peak of the Atlantic hurricane season approaches. A score of 100 represents a perfect prediction while a score of 0 more or less means that the forecasting technique offers no improvement with respect to a climatological forecast.

CSU: Colorado State University, TSR: Tropical Storm Risk, NOAA: National Oceanic and Atmospheric Administration.

There have been some recent news articles regarding the prediction for an active 2024 hurricane season, but it is important to understand why these claims are being made and what it might mean for Cat Bonds.

In a lot of the predictions, they will talk about the number of hurricanes, and in particular the "ACE". ACE predictions tend to be more accurate to reality, as it is a more general term for amount of hurricane energy in a season, rather than saying the specific number of events that may happen or what strength they may be.

It is also key to understand that while it is important to know the number of hurricanes that

The most recent predictions from the ECMWF² are based on two factors; 1) the timing of the El Niño/La Niña, and 2) the Warm Sea Surface Temperatures, both of which impact hurricane activity.

may form – for Cat Bonds the number of hurricanes that make landfall are more relevant. This is something that is even harder to predict (and indeed something that agencies do not put a number out for), moreover it matters greatly where a hurricane makes landfall (i.e. is it in a sparse of densely populated area).

¹ Accumulated Cyclone Energy, which is a measure of hurricane energy released in a season, it is essentially a

summation of the strength of a hurricane over time that it exists

² European Centre for Medium-Range Weather Forecasts.





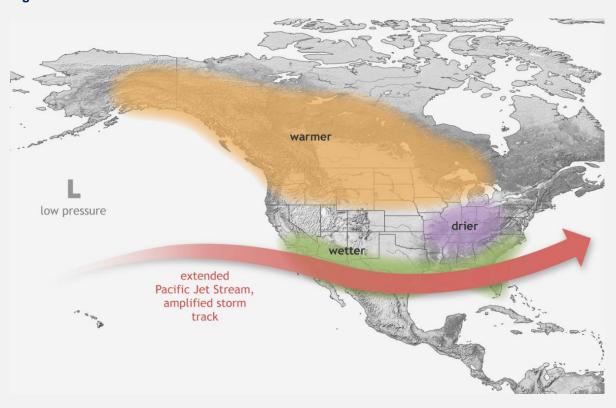
El Niño/La Niña

Sometimes referred to as the ENSO (El Niño Southern Oscillation) cycle, it is a naturally occurring phenomenon in the Pacific where waters are warmer than usual (El Niño) or cooler than normal (La Niña). Their frequency is not regular, with their duration and periodicity being predictable or regular. A typical El Niño lasts 9-12 months, with a typical La Niña lasting 1-3 years (of course it is possible for these

conditions to last a shorter/longer amount of time). Usually, they form during March-June, reach peak intensity around December-April, then weaken in May-July.

The so called "strength" of the El Niño/La Niña also matters, this is simply the level of heightened heating/cooling in the Pacific. So, while this is a phenomenon monitored in the Pacific, it is a fair question as to why this should matter for the Atlantic Hurricane basin.

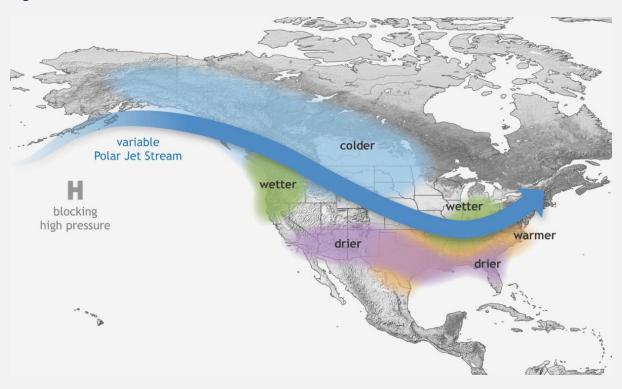
Figure 2: El Niño



Source: https://oceanservice.noaa.gov/facts/ninonina.html. As at 14 March 2024.



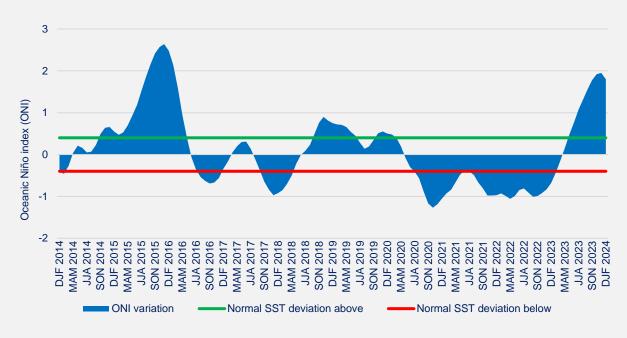
Figure 3: La Niña



Source: https://oceanservice.noaa.gov/facts/ninonina.html. As at 14 March 2024.

A strong El Niño helps to inhibit hurricane formation in the Atlantic as the vertical wind shear and steering flows are knocking over hurricanes as they try to form, and also working to push them away from the US coast line. When we move into a La Niña, these trade winds move further north essentially reducing/removing the inhibition of hurricane formation.

Figure 4: Cold & Warm Sea Surface Temperature (SST) deviations



Source: https://www.cpc.ncep.noaa.gov/data/indices/oni.ascii.txt. As at 14 March 2024.

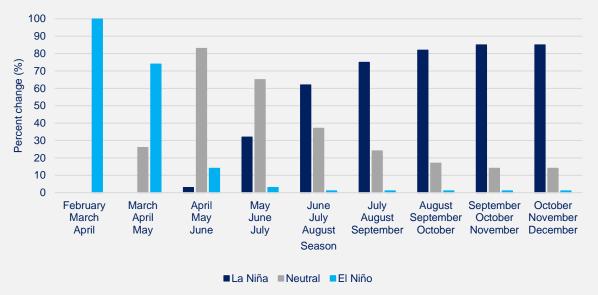


Using the latest data from NOAA, one can plot the 3-month average of the El Niño sea surface temperature anomalies. On the far right hand side of the plot, we see the ONI variation from the past few months (DJF 2024 = Dec 2023-Jan-Feb 2024) showing that we are above the normal (i.e. an El Niño) but that it is reducing. If/when it crosses below the x-axis this denotes that it is moving into a La Niña, with the "strength" being how far it deviates from the x-axis. Roughly speaking a deviation of greater than +/-0.5 degrees indicates that there will be influence from an El Niño/La Niña, i.e. a non-neutral state.

So if we are currently in an El Niño cycle (which is good for fewer hurricanes) we can see that it looks as though the strength of this is reducing, and that this reduction will continue (as it is part

of a natural process), which means that there will then be less inhibition. The crux of the issue is not "will a La Niña form" but better conceptualised as "when will the El Niño be reduced" and it is this "when" that is the real driver. While the Atlantic hurricane season officially lasts from 1 June to 30 November, the peak of the activity is August, September, and October, meaning if the El Niño reduces too much before August, there will be the chance for higher hurricane activity. The longer the El Niño remains the longer there will be a suppression of the hurricane activity. The specifics of exactly when this will happen are hard to predict but will be a key issue to keep an eye on, and will make a big difference in the level of heightened risk.

Figure 5: ENSO probabilities



Source: https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-cpc_plume. As at 14 March 2024.

This latest prediction from NOAA shows that a La Niña is expected, but there is uncertainty around the *when* and the strength of it, with there even being a ca. 20% probability that during the peak of the season it will be a "neutral" phase.



Warm Sea Surface Temperatures

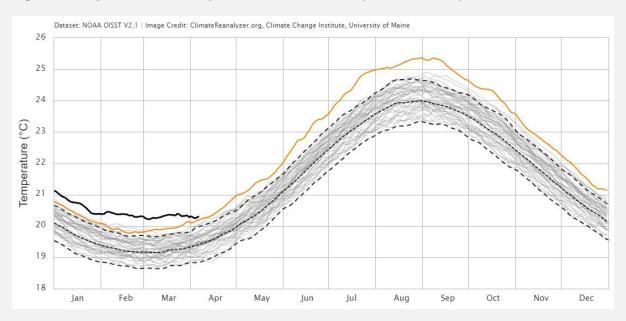
As mentioned above the temperature of the oceans is an important factor for hurricane formation, with the warmer oceans allowing for more hurricanes to form, or for them to become stronger, or allowing them to travel further.

Figure 6 tracks the current North Atlantic mean sea surface temperature. The black line is this year while the orange line was 2023. At present



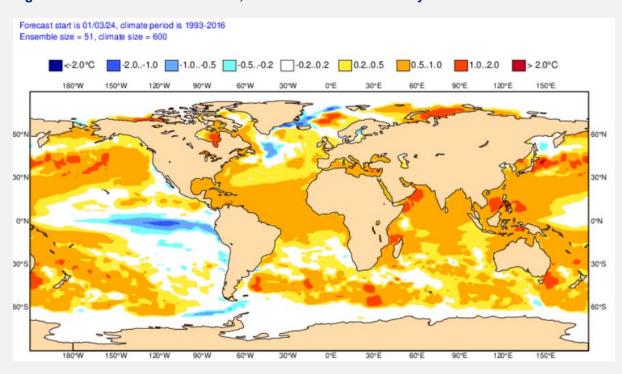
the mean sea surface temperature is at record highs. Figure 7 from the ECMWF³ shows their current prediction of what the sea surface temperatures might look like in July with it showing that in the main part of the Atlantic temperatures are predicted to be 0.5 to 1 degree warmer than average.

Figure 6: Daily sea surface temperature, North Atlantic (0-60°N, 0-80°W)



Source: https://climatereanalyzer.org/clim/sst_daily/. As at 5 April 2024.

Figure 7: ECMWF seasonal forecast, mean forecast SST anomaly



Source: ECMWF. As at 14 March 2024.

³ European Centre for Medium-Range Weather Forecasts.





Hurricanes are a stochastic process

From the above and current press, there is the thought that 2024 will be a very active year in terms of hurricanes in the Atlantic. While this may be true, it is important to take a number of other factors into consideration. Firstly, hurricanes are a stochastic (random) process, therefore, we cannot say with absolute certainty that 2024 will be a "big year" for hurricane exposed Cat Bonds. What we are able to say is that the conditions for hurricane formation are favourable.

What ultimately matters for Cat Bonds is "do large hurricanes make landfall in populated areas" which is a hard question to answer with hurricane forecasts, as not only do hurricanes need to form, they need to be of sufficient size, and move in a given direction.

Figure 8 is pulling together a number of factors mentioned above, in addition to plotting information on actual hurricane activity over the past 10 years:

- ENSO index (blue), positive numbers indicate El Niño and thus hurricane suppression, below indicates La Niña and reduced suppression
- Sea Surface Temperature Anomaly (grey), based on mean from 1982 to now, so is the degrees above/below the long term average
- Count of land falling hurricane events to cause losses (yellow)
- Sum of industry losses caused by hurricanes in that month (orange)

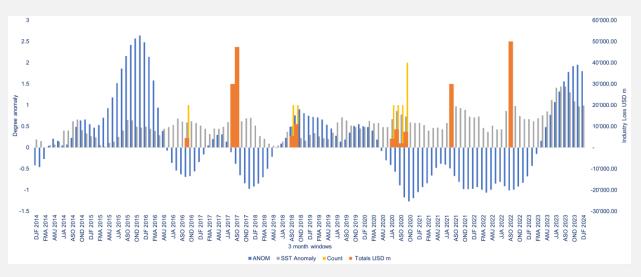


Figure 8: ENSO vs. industry 2014-present

Source: Twelve Capital, Artemis. As at 8 April 2024.





Summary

While the matter is complex, some inferences can be taken:

- ENSO has an effect on landfalling hurricane probability, but it seems to be more of a frequency driver than severity i.e. hurricanes still need to hit populated areas to cause damage.
- The 2017 spike in industry losses is from Hurricanes Irma and Maria (ca. USD 25bn each) and ASO⁴ 2022 is Hurricane Ian (USD 49bn). Both of these, on an industry basis, are below where Cat Bonds usually attach.
- While the current conditions increase the probability of hurricanes, it is much harder to show what the impact is on very large events. Major landfalling hurricanes are not common and an increase in their probability still does not make them common.

The catastrophe modelling used for calculating the Expected Loss of a Cat Bond uses

simulations covering a variety of scenarios in order to account for years with higher levels of activity and those with lower. Twelve Capital also applies its own view of risk on top of the base modelling as well. The pricing of a bond is based on a longer term view than a single season, given the difficulty in prediction, as such Twelve Capital feels that the spread being paid compensates for the risk taken.

When we look at further forecasts related to the Atlantic hurricane season, Twelve Capital would be happy to provide summaries and commentaries once most agencies provided their forecasts. In addition, we will again issue regular event updates during the hurricane season, first starting on a bi-weekly basis and then moving to a weekly frequency once we approach the peak of the season. Towards the end of the season in November we are happy to issue a 2024 retrospective.

Key risk associated with investments in Cat Bonds include

Concentration in one industry risk: When a portfolio is reliant on one industry or market segment (i.e., insurance industry), this creates concentration risk. Thus, it increases the likelihood that a single impact can have a big effect.

Event risk: Should an insured event occur and the defined threshold values be exceeded, then the value of a specific ILS instrument may decrease to the extent of a total loss.

Liquidity risk: Potentially situationally dependent, certain instruments may not be liquidated in a reasonable time frame.

Model risk: The calculated event probability of certain events is based on risk models. These only represent an approximation of reality and may be fraught with uncertainty and errors. Consequently, event risks can be significantly under- or over-estimated.

Valuation risk: Due to a wide variety of market factors, there is no guarantee that the value determined by the Administrator will represent the value that can be realised on the eventual disposition of the investment or that would, in fact, be realised upon an immediate disposition of the investment.

⁴ August, September, October.



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