The 2023 Hurricane Season

Introduction

Tropical cyclones are intense circular storms which originate over warm tropical oceans. Commonly known as hurricanes, they are also named “typhoons” in the western Pacific, and “cyclones” in the Bay of Bengal and northern Indian Ocean. For the purposes of this paper they will all be referred to as hurricanes.

Hurricanes have been known about and reported for many centuries, but systematic recording really only started in the mid 19thC.

Categorisation of hurricanes by wind speeds also vary in different parts of the world. Here we will refer to the Saffir-Simpson scale, which is always used for Atlantic hurricanes. The scale is based on 1-minute sustained wind speeds, ranging from Category 1 with winds of at least 74 mph, up to category 5 where winds reach 157 mph.

The purpose of this paper is to examine trends in hurricane frequency and intensity, using official data, as well as summarising the latest science.

Chapter 1 looks at how observation practices have changed over time, and the effect they have had on reported data. Chapters 2 and 3 present the data for US landfalling and Atlantic hurricanes respectively.

Chapter 4 presents global trends. Finally Chapter 5 reviews the latest IPCC findings in AR6.

1) Changes in Observation Methodology

Since the 19thC, the way we observe, monitor and measure hurricanes has changed out of all recognition, as Hagen & Landsea have summarised (1):

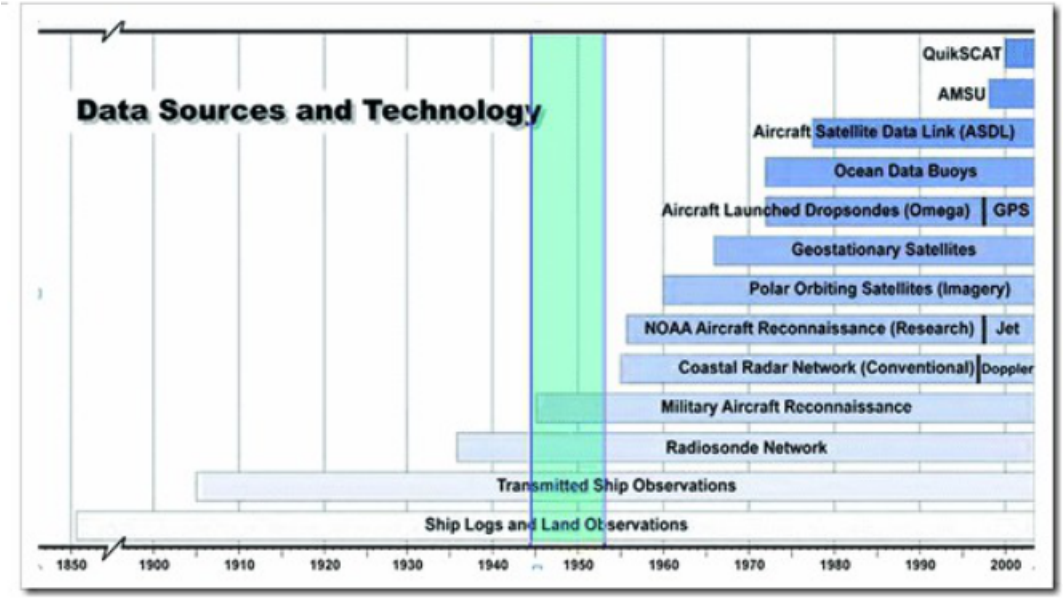


Figure 1

The Atlantic hurricane database (or HURDAT) is maintained by the US National Oceanic & Atmospheric Administration (NOAA), and extends back to 1851. However, because tropical storms and hurricanes spend much of their lifetime over the open ocean - some never hitting land - many systems were "missed" during the late 19th and early 20th Centuries Starting in 1944, systematic aircraft reconnaissance was commenced for monitoring both tropical cyclones and disturbances that had the potential to develop into tropical storms and hurricanes. This did provide much improved monitoring, but still about half of the Atlantic basin was not covered. Beginning in 1966, daily satellite imagery became available at the National Hurricane Center, and thus statistics from this time forward are most complete (1)

For hurricanes striking the USA Atlantic and Gulf coasts, one can go back further in time with relatively reliable counts of systems because enough people have lived along coastlines since 1900. (2)

In the Pacific and Indian Oceans, early coverage was even less comprehensive. Full satellite coverage may not have been available till around 1980 (3)

This lack of coverage has a particular impact on the reporting of short lived storms, according to Vecchi & Knutson (4):

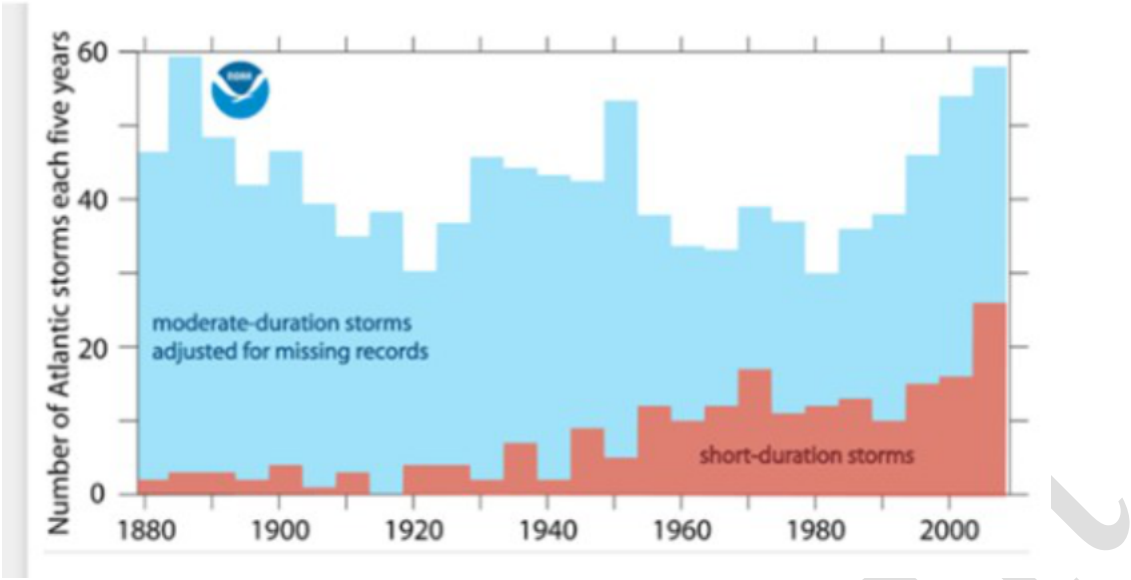


Figure 2

When allowance is made for these storms that were "missed" in earlier decades, Vecchi & Knutson concluded that:

"after adjusting for such an estimated number of missing storms, there is a small nominally positive upward trend in tropical storm occurrence from 1878-2006. But statistical tests reveal that this trend is so small, relative to the variability in the series, that it is not significantly distinguishable from zero (Figure 2). Thus the historical tropical storm count record does not provide compelling evidence for a greenhouse warming induced long-term increase".

It is not only the number of storms which tended to be underestimated. Hagen & Landsea demonstrated that the strength of the most intense, Cat 5 hurricanes were also underestimated prior to the satellite era:

Observations of the peak intensity in strong hurricanes were much less common during the late 1940s/early 1950s when compared with recent years because the ability to measure the central pressure and peak winds in major hurricanes was very limited during the late 1940s/early 1950s. A Category 5 designation would be possible if a hurricane made landfall as a Category 5 at or very near a weather station, or if a ship passed through the center while at Category 5 intensity. Aircraft reconnaissance was generally only capable of recording Category 4 conditions at most because of the inability to penetrate intense hurricanes.

They re-analysed ten Cat 5 hurricanes, which occurred between 1992 and 2007, and found that only two would have been categorised as Cat 5, using 1940s technology. Both of these, Andrew and Mitch, made landfall at Cat 5.

They concluded that there are likely to have been several Category 4 and 5 hurricanes misclassified as being weaker prior to the satellite era (1)

It is clear from all of the above that both the frequency and intensity of hurricanes were underestimated prior to the satellite era, making measurement of long term trends extremely difficult.

2) US Landfalling Hurricanes

As already noted, the longest record with reliable counts of hurricanes is for the US Atlantic and Gulf coasts.

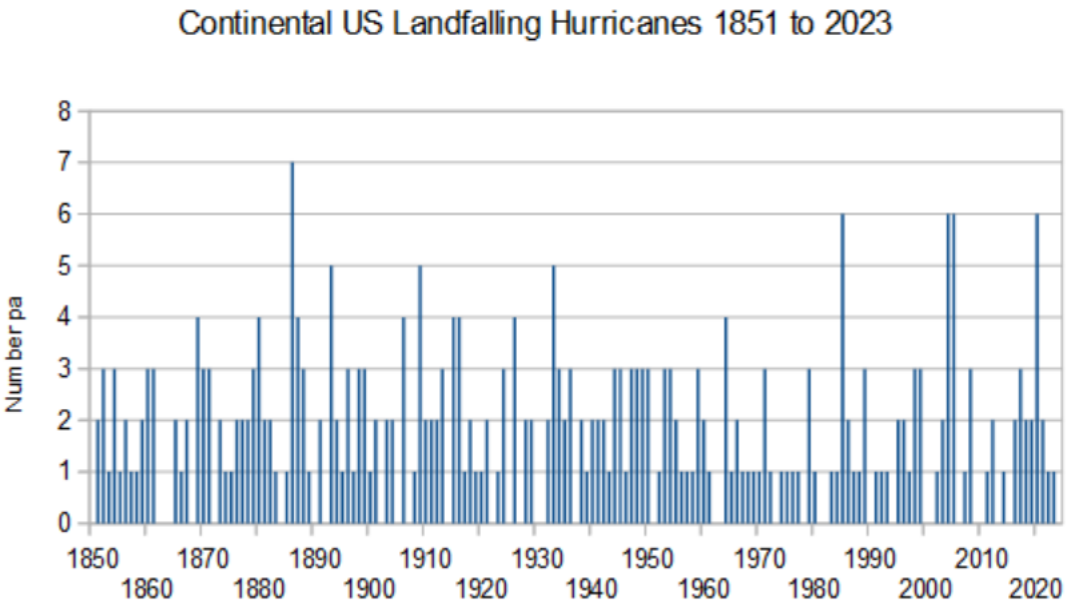
The US Hurricane Research Division (HRD) which is part of NOAA, has compiled lists of US landfalling hurricanes, which go back to 1851. However, although many parts of the coastline were populated as far back as 1851, other such as Texas and Florida were still sparsely populated until around 1900. Therefore the list may be incomplete up to 1900.

There is also the issue of the Civil War years, with no hurricanes listed at all in 1862 to 1864. Clearly this is not a reliable count.

Considerable re-analysis work has been carried over the years by the HRD, using widespread records to reassess the original measurements of wind speeds and central pressure. In the past it was rare for such measurements to be taken at the exact centre or strongest part of the storm. By re-analysing available data, the scientists have been able to piece together the wider picture, and thus estimate the missing parts.

Figure 3 shows all hurricanes since 1851 which have made landfall as hurricanes on the US mainland, and all major hurricanes (defined as Cat 3 and over on the Saffir-Simpson scale).

Neither dataset shows any evidence of increasing frequency. The busiest decades for major hurricanes were the 1940s and 1890s, whilst the most recent decade of 2011 to 2020 recorded five, which is just below average.



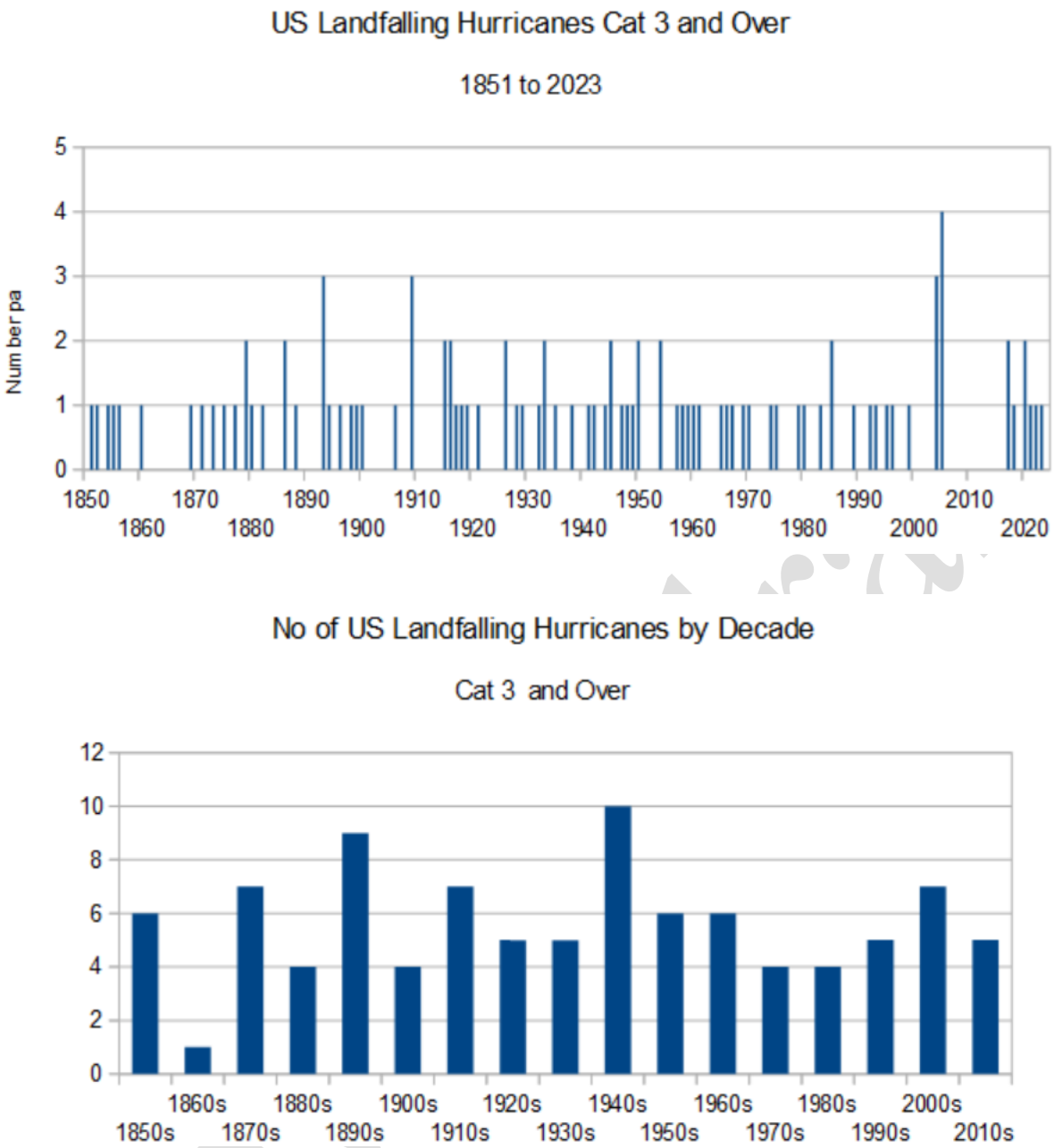


Figure 3 – US Landfalling Hurricanes
US Hurricane Research Division (5)

Prior to the satellite era, hurricane wind speeds were usually estimates based on the central pressure of the hurricane, which could be more readily measured. It would have been extremely rare for an anemometer to be located at the exact point where wind speeds were at their highest, and such instruments were unable to withstand the strongest winds.

However in recent years wind speeds have been calculated using satellite and aircraft data. This has

created an anomaly where estimated of wind speeds for hurricanes now tend to be higher than past ones with similar central pressure.

The GWPF's The 2022 Hurricane Season (6) highlighted the fact that some of the stronger historical hurricanes with similar estimated wind speeds to recent ones had much lower central pressure – see Table 1:

Table 1: Pressure and windspeed in selected US hurricanes

Hurricane	Year	Central pressure (mb)	Estimated wind speed (mph)
Ian	2022	940	150
Galveston	1915	940	132
Hazel	1954	940	132
Indianola	1886	925	150
Great Miami	1926	929	144
Laura	2020	939	150

The same discrepancy has arisen with Hurricane Idalia, the Cat 4 storm which hit Florida in August 2023. The official record states that Idalia has central pressure of 949 Mb, and sustained winds of 125 mph.

However the Great Miami Hurricane of 1926 was also estimated to have had winds of 125 mph, yet the central pressure was measured at 930 Mb. Similarly, another catastrophic Florida hurricane, Okechobee in 1928, also had winds of 125 mph and an even lower central pressure of 929 Mb.

Evidence is steadily mounting that wind speeds in the pre-satellite era were underestimated in comparison with hurricanes nowadays. For that reason it is worth looking at the time distribution of the most intense hurricanes (as maesured by central pressure), as in Figure 4.

The two most intense were the Labor Day hurricane in 1935, and Camille in 1969. These are also the two strongest hurricanes measured by wind speeds. As with the frequency of hurricanes, the data clearly shows no evidence that hurricanes are becoming more intense, or extremely intense ones are becoming more common.

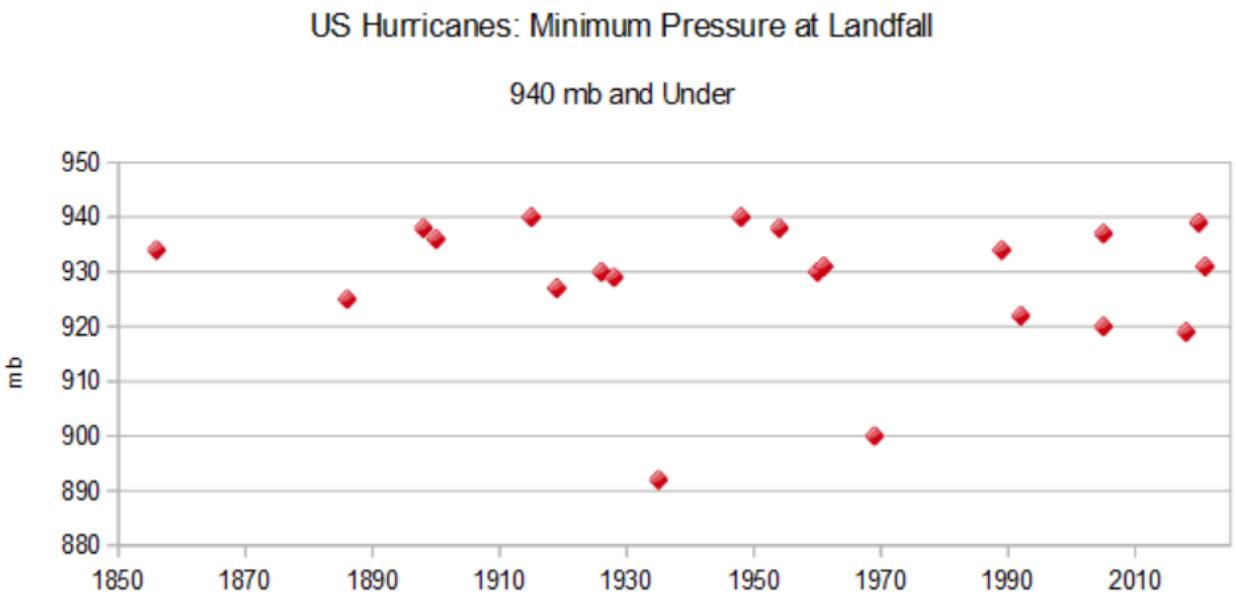
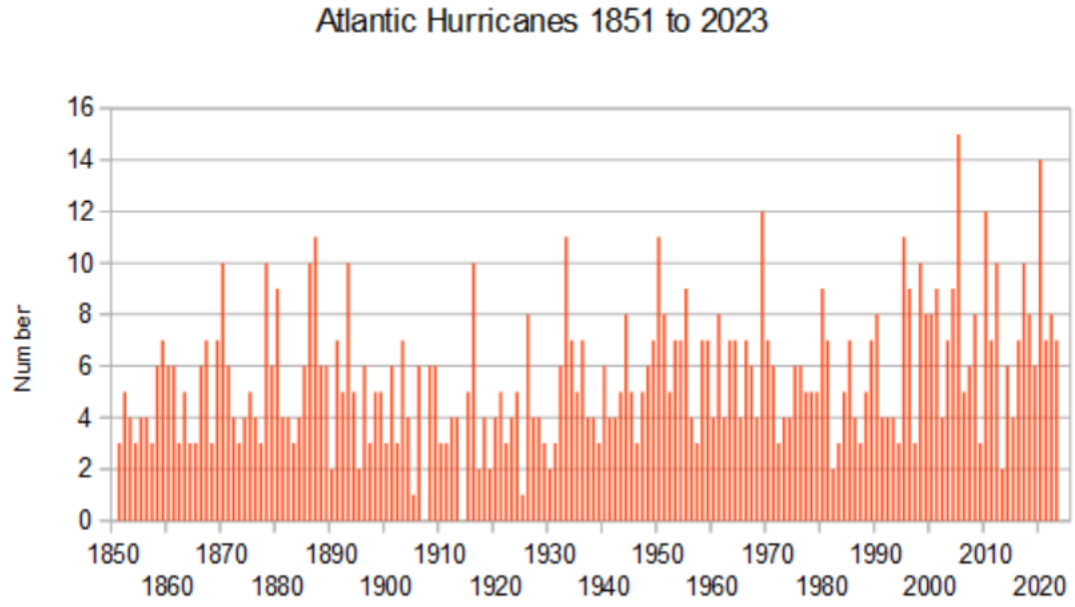


Figure 4 – Most Intense US Landfalling Hurricanes (5)..

3) Atlantic Hurricanes

There were seven Atlantic hurricanes in 2023, including three major ones. Both figures are slightly below the 30-year average.



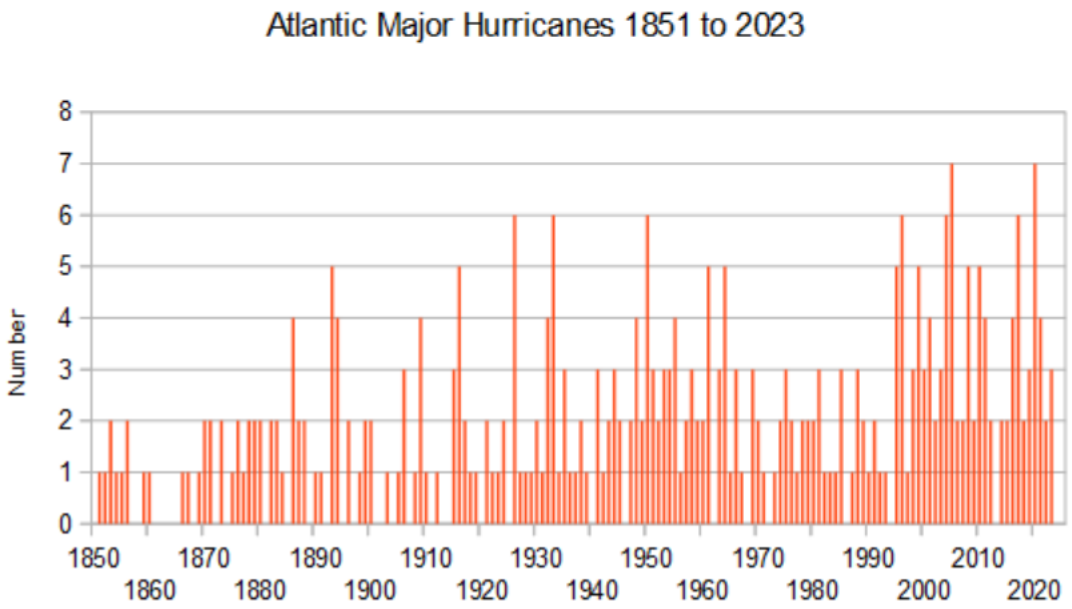


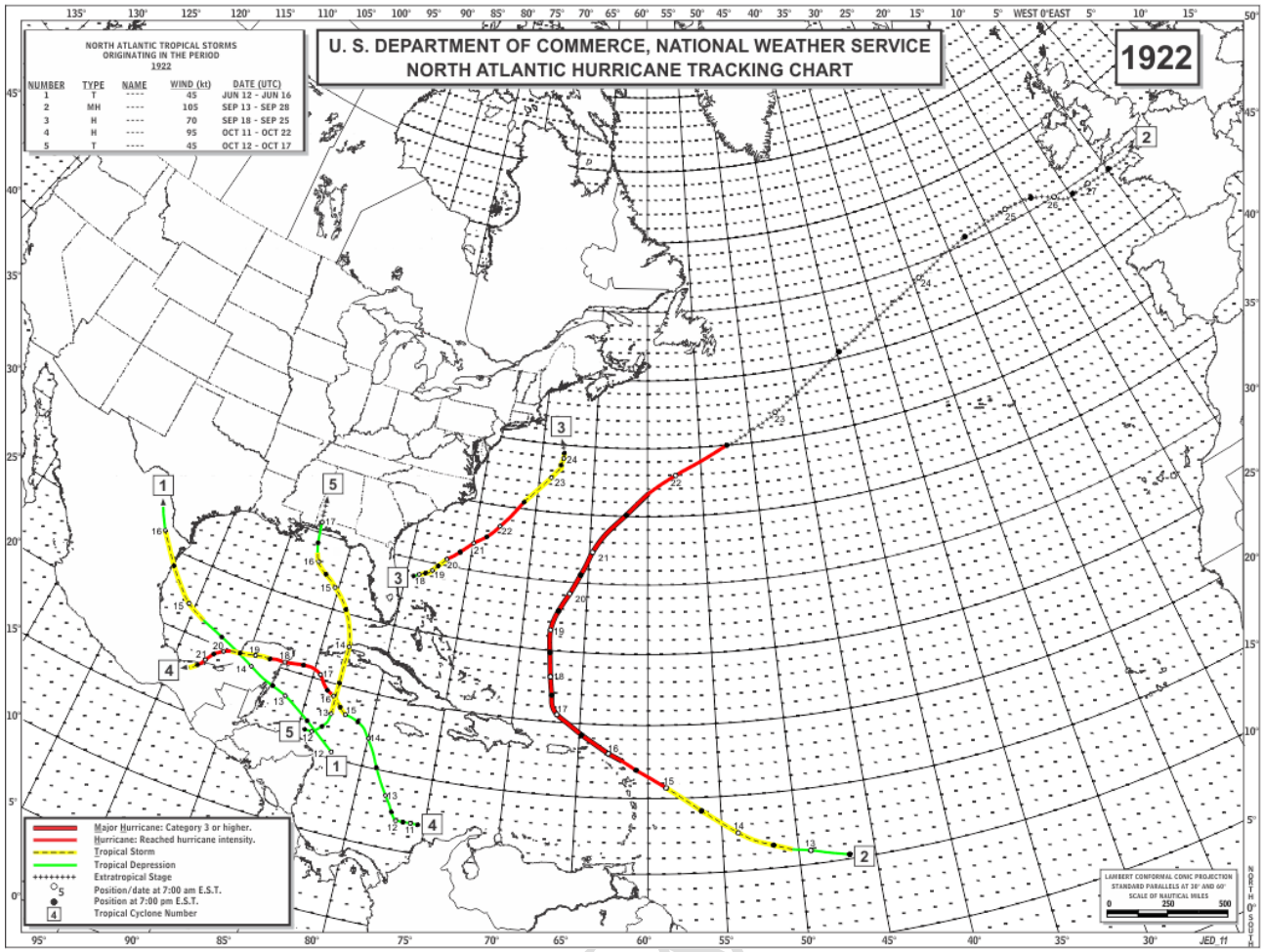
Figure 5 – Number of Atlantic Hurricanes (7)

As already noted, many hurricanes in the Atlantic were missed prior to the satellite era. Vecchi et al have shown that when these missing hurricanes are accounted for, increases in basin-wide hurricane and major hurricane activity since the 1970s are not part of a century-scale increase, but a recovery from a deep minimum in the 1960s–1980s. (4)

NOAA concur with Vecchi's conclusions, stating: (8)

There is no strong evidence of century-scale increasing trends in U.S. landfalling hurricanes or major hurricanes, Similarly for Atlantic basin-wide hurricanes (after adjusting for observing capabilities), there is not strong evidence for an increase since the late 1800s in hurricanes, major hurricanes, or the proportion of hurricanes that reach major hurricane intensity.

This discrepancy of missing hurricanes can be visually observed in Table 4 and 5. In 1922 there were five tropical storms, including three hurricanes recorded in the Atlantic, compared to fourteen and eight in 2022. But as the tracking charts for the two years show, all of the ones in 1922 passed close to land. By contrast most last year stayed well away from land:


U. S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
NORTH ATLANTIC HURRICANE TRACKING CHART
1922
NORTH ATLANTIC TROPICAL STORMS ORIGINATING IN THE PERIOD 1922
NUMBER TYPE NAME WIND (kt) DATE (UTC)
1 T ---- 45 JUN 12 - JUN 16
2 MH ---- 105 SEP 13 - SEP 28
3 H ---- 70 SEP 18 - SEP 25
4 H ---- 95 OCT 11 - OCT 22
5 T ---- 45 OCT 12 - OCT 17
Major Hurricane: Category 3 or higher.
Hurricane: Reached hurricane intensity.
Tropical Storm
Tropical Depression
Extratropical Stage
Position/date at 7:00 am E.S.T.
Position at 7:00 pm E.S.T.
Tropical Cyclone Number
LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS AT 16° AND 60°
SCALE OF NAUTICAL MILES
0 250 500
JED 11

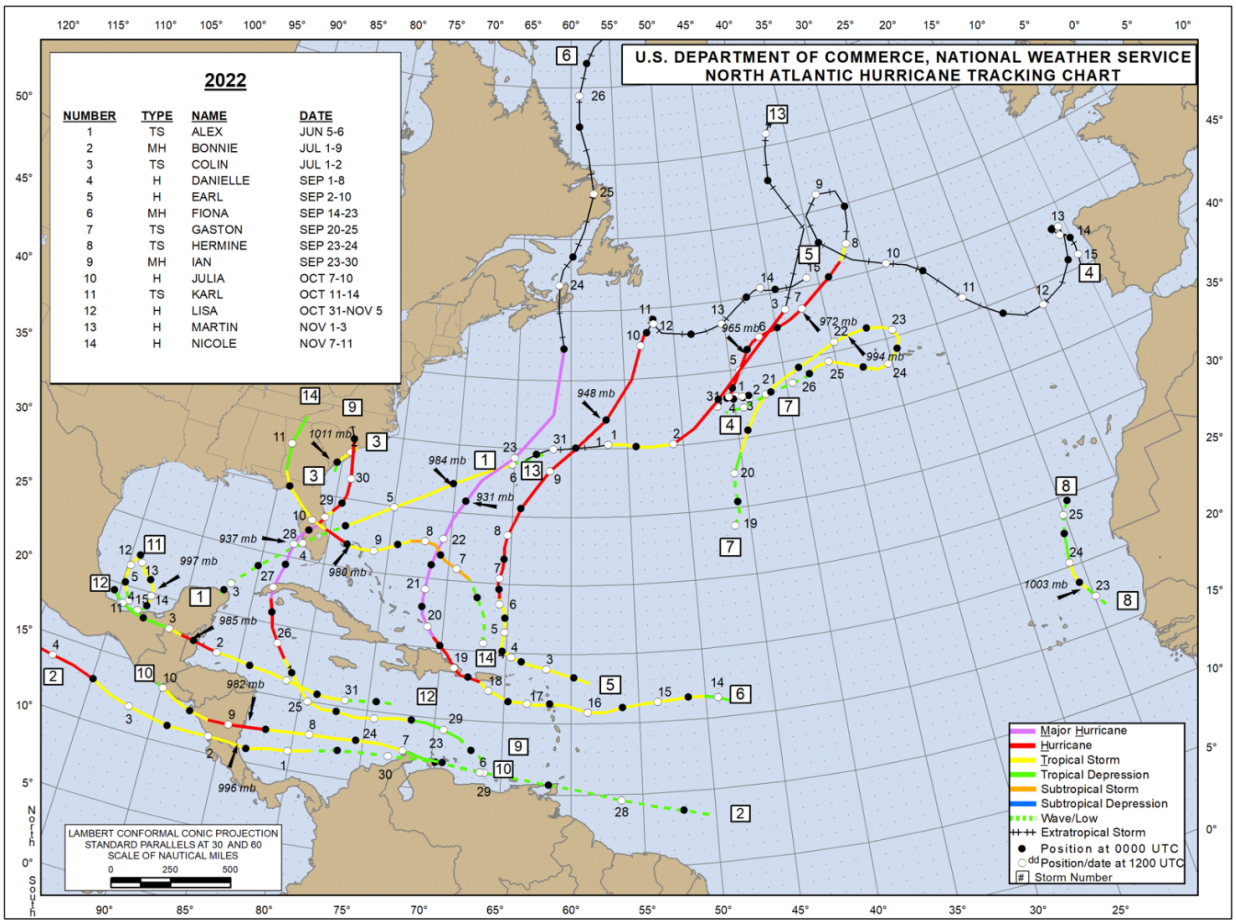


Figure 6 – Atlantic hurricane tracks (9)

The deep minimum in Atlantic hurricane activity in the 1960s to 1980s is associated with the cold phase of the Atlantic Multidecadal Oscillation (AMO). According to NOAA, the number of tropical storms that mature into severe hurricanes is much greater during the warm phase of the AMO than during cool phases,at least twice as many. (10)

It has also been suggested that the increase in tropical storm frequency in the Atlantic basin since the 1970s has been at least partly driven by decreases in aerosols from human activity and volcanic forcing (8).

It is however worth noting that the previous cold phase of the AMO, between the 1900s to 1920s also coincided with reduced hurricane activity.

4) **Global Trends**

As noted, comprehensive observation of hurricanes worldwide probably did not start till around 1980.

Globally there were 46 hurricanes in 2023, compared to an average of 47 since 1980. Major hurricanes were above average at 31, but have been below average over the last three years.

The number of major hurricanes increased during the 1990s, mainly because of the ending of the cold phase of the AMO. Since then trends have been flat.

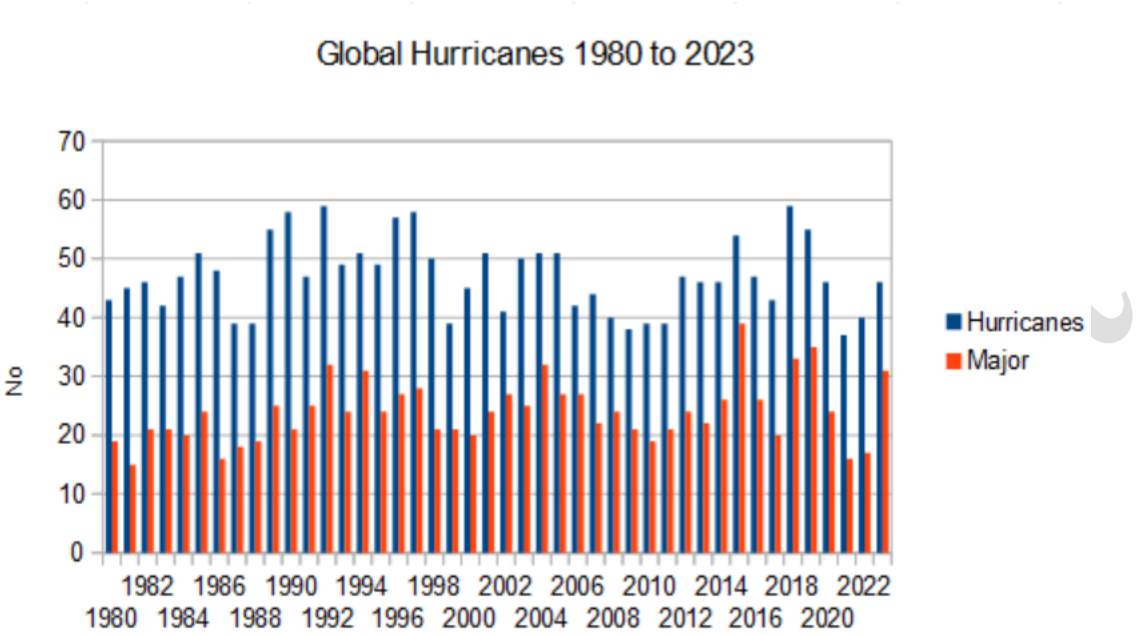


Figure 6 – Global Hurricane Frequency

The Australian Bureau of Meteorology maintain records of hurricanes back to 1971. There is a clearly declining trend in both overall numbers and severe storms (equivalent to Cat 3).

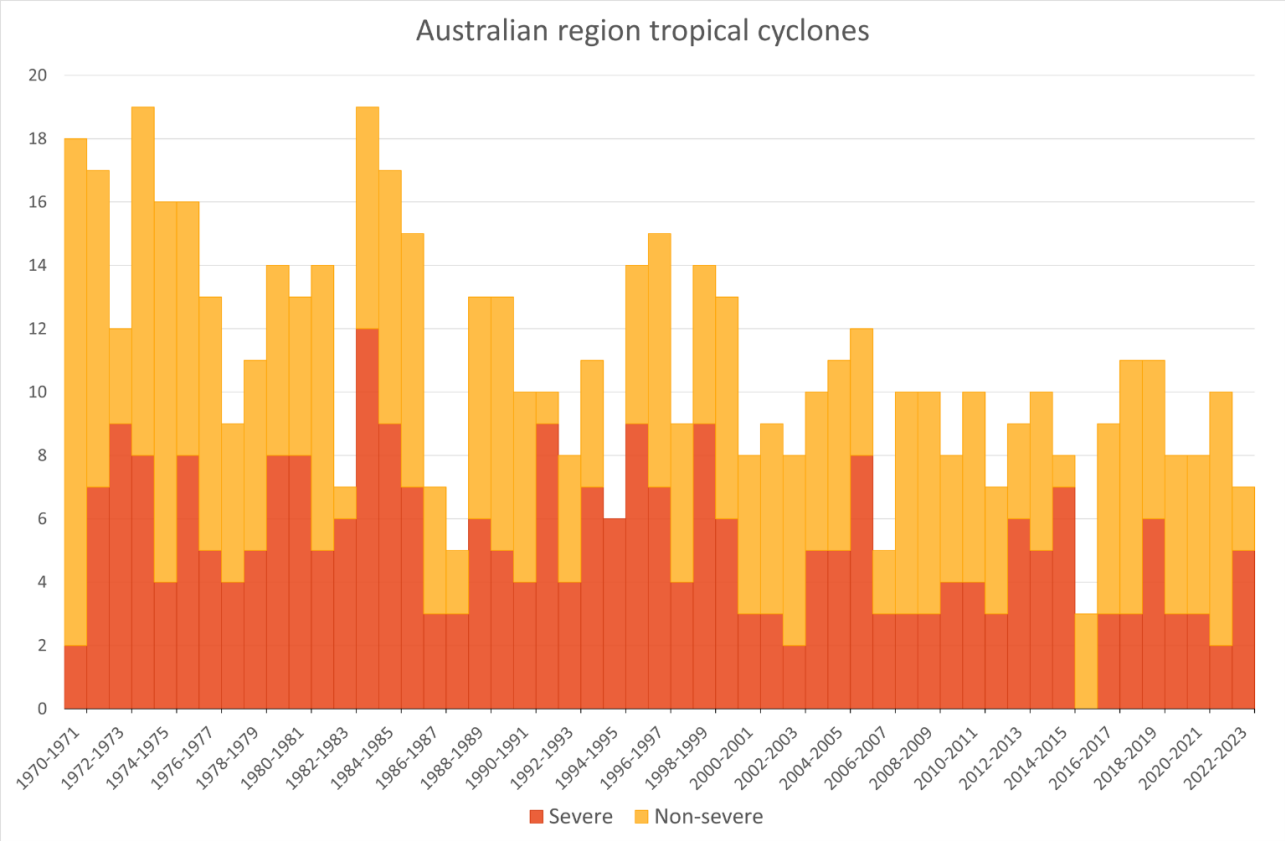


Figure 7 – Hurricane Frequency in Australian Region (12)

5) **What do the IPCC say?**

In AR6, the IPCC stated (13):

"*There is low confidence in most reported long-term (multi-decadal to centennial) trends in TC frequency- or intensity-based metrics due to changes in the technology used to collect the best-track data.*"

They did note that the global proportion of major hurricanes had increased over the last four decades. However, as already shown, this is a product of the AMO, and not part of any long term trend.

AR6 made two other claims. The first was that the latitude where hurricanes reach their peak intensity had shifted northwards.

The second was that climate change had increased heavy precipitation associated with tropical cyclones. However, this claim was derived from highly controversial weather attribution models; the IPCC were unable to find any evidence to support this claim.

Hurricanes 2023

References

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