Claim: Global warming is causing more hurricanes and stronger hurricanes

The long-term linear trend in the number and intensity of global hurricane activity has remained flat. Hurricane activity does vary year-to-year and over longer periods as short-term ocean cycles like El Nino/La Nina and multidecadal cycles in the Pacific (PDO) and Atlantic (AMO) ocean temperature regimes favor changes in activity levels and some basins over others.

Credible data show this constant flat trend pattern is true despite much better open ocean detection than before the 1960s when many short-lived storms at sea would have been missed as there were no satellites, no aircraft reconnaissance, no radar, no buoys and no automated weather stations back then.

Landfall counts are more reliable. This data shows that the number of U.S. landfalling hurricanes and major hurricanes has been on the decline since the late 1800s. This current decade was the quietest one for landfalling hurricanes (behind the 1970s) and major hurricanes (behind only the 1860s).

However, the impacts on the United States has varied considerably with time, with very active seasons giving way to long lulls during which the public forgets the lessons from past storms and the risks of settling in vulnerable areas. The regions targeted vary too. The period from 1926 to 1935 was very active in the Gulf area. After decades of no impact storms, there were 8 major devastating storms on the east coast from 1938 to 1960 then a 25-year lull until Gloria and then Hugo began another active era of increased activity.

This century Isabel in 2003, Charley, Frances, Ivan and Jeanne in 2004 and Dennis, Katrina, Rita and Wilma in 2005 all made landfall on the mainland. 2005 holds the record for 5 category 4 and 4 category 5 impact storms. At the time, some speculated this was the new norm for the Atlantic due to climate change. However, after the active 2005 season and before the landfall of two major storms on the U.S. in 2017, the U.S. had gone 4324 days (just short of 12 years) without a major hurricane landfall, exceeding the prior record 8-year lull in the 1860s.

Harvey in 2017 was the first hurricane to make landfall in Texas since Ike in 2008 and the first Category 4 hurricane in Texas since Hurricane Carla in 1961. Note that there has been no increase in Texas in either hurricanes or major hurricanes. In 2017, Irma was the first landfalling hurricane and major hurricane in Florida since Wilma in 2005. This also was also after a record lull – 4439 days. The previous record lull back to 1851 was 2191 days from 1979 to 1985.

Michael whose tight core winds did major damage on a portion of the Florida panhandle in 2018 had the 20th lowest pressure for an Atlantic storm and was third lowest pressure for a storm making landfall behind the Labor Day Hurricane in 1935 and Hurricane Camille in 1969.

In short, there is nothing unique or unprecedented about recent hurricane seasons or hurricanes. Active Atlantic seasons like 2004 and 2005 and 2017 were similar to 1893, 1926, 1933, 1950 and 1995. 1893 had 5 major hurricanes two of which both caused over 2000 deaths making that year the deadliest on record at that time. 7 years later in 1900, the Great Galveston hurricane killed up to 12,000, making it the most deadly in U.S. history.

Strong hurricanes like Maria in 2017 with devastation on the Caribbean islands are not unique. The Great Hurricane of 1780 killed 27,500 while ravaging the Caribbean islands with winds estimated over 200 mph. It was one of three hurricanes that year with death tolls over 1000.

The heavy rains associated with slow moving Harvey and Florence lead to claims that slow movement was related to climate change. Careful analysis of the data shows a flat linear trend in storm motion on land for over the last half century.

The most recent (2018) U.S. Government analysis of the 36 most costly hurricane disasters in U.S. history, showed that increasing damages are due to increasing population density and infrastructure vulnerability, not due to storm intensity.

Chris Landsea (NOAA) in 2011 noted “instead of a dramatically increasing trend of hurricane damages, destruction from these storms

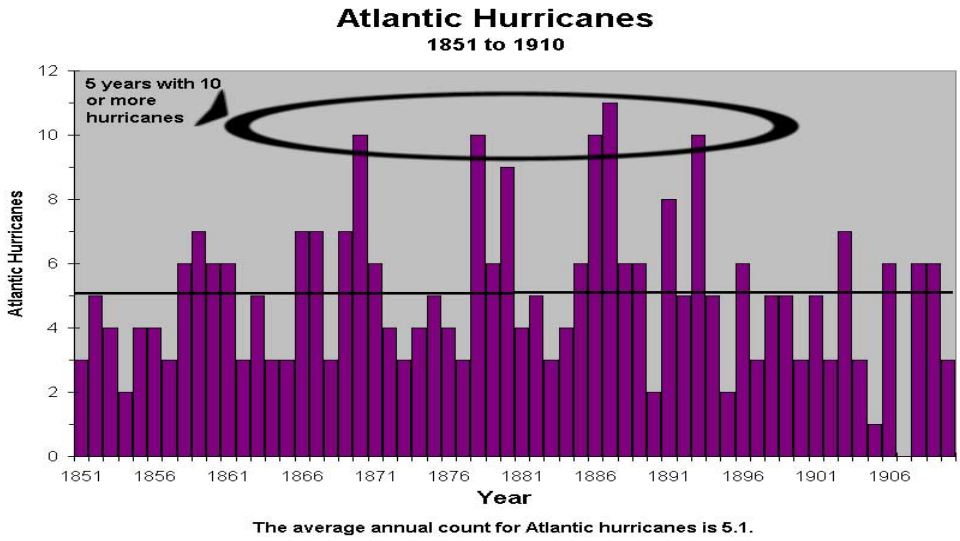
varies on a decade-to-decade timescale with more damages in the early 1900s, low damages during the late 1900s to early 1920s, much higher destruction in late 1920s to the early 1960s, and reduced damages from the late 1960s to early 1990s. Certainly, the U.S. hurricane damages from 1996 to 2005 were quite high, but now it is evident that these were quite similar to the decade of 1926 to 1935. So, after straightforward consideration of the non-meteorological factors of inflation, wealth increases, and population change, there remains no indication that there has been a long-term pick up of U.S. hurricane losses that could be related to global warming today. There have been no peer-reviewed studies published anywhere that refute this."

Clearly, there is no evidence for more hurricanes and stronger hurricanes.

CLAIM: The current level and intensity of hurricane activity is unprecedented.

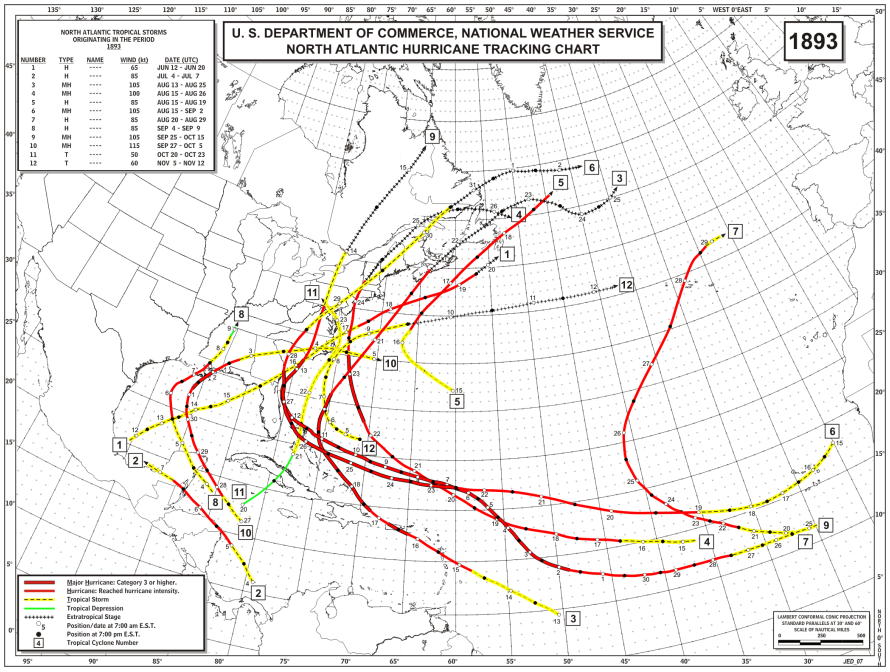
Nothing is new in weather. Great Colonial hurricanes in the northeast with storm surges up to 20 feet occurred in 1635 and 1675. A Katrina like storm made landfall in Louisiana in 1722 with major flooding and damage in Louisiana. The Great Chesapeake storm in 1769 like Isabel in 2003 brought major flooding to North Carolina and Virginia. In the Caribbean, the Great Hurricane of 1780 killed an estimated 27,500 people while ravaging the islands of the eastern Caribbean with winds estimated to top 200 mph. It was one of three hurricanes that year with death tolls greater than 1000.

The late 1880s and 1890s were very active.

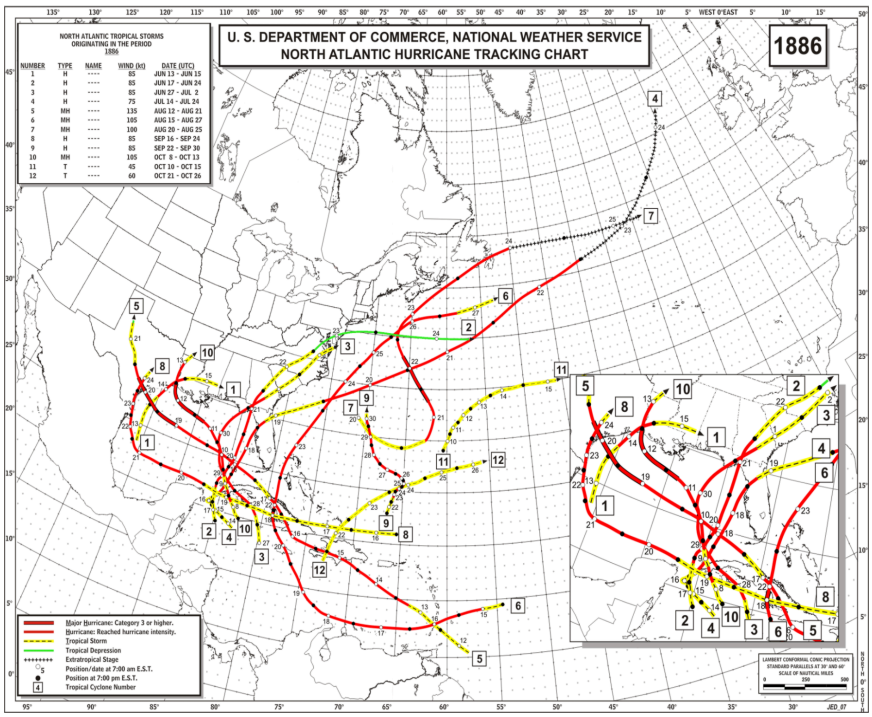


The average annual count for Atlantic hurricanes is 5.1.

1893, had at least 10 hurricanes. Of those, 5 became major hurricanes. Two of the hurricanes caused over two thousand (2000) deaths in the United States; at the time, the season was the deadliest in U.S. history.



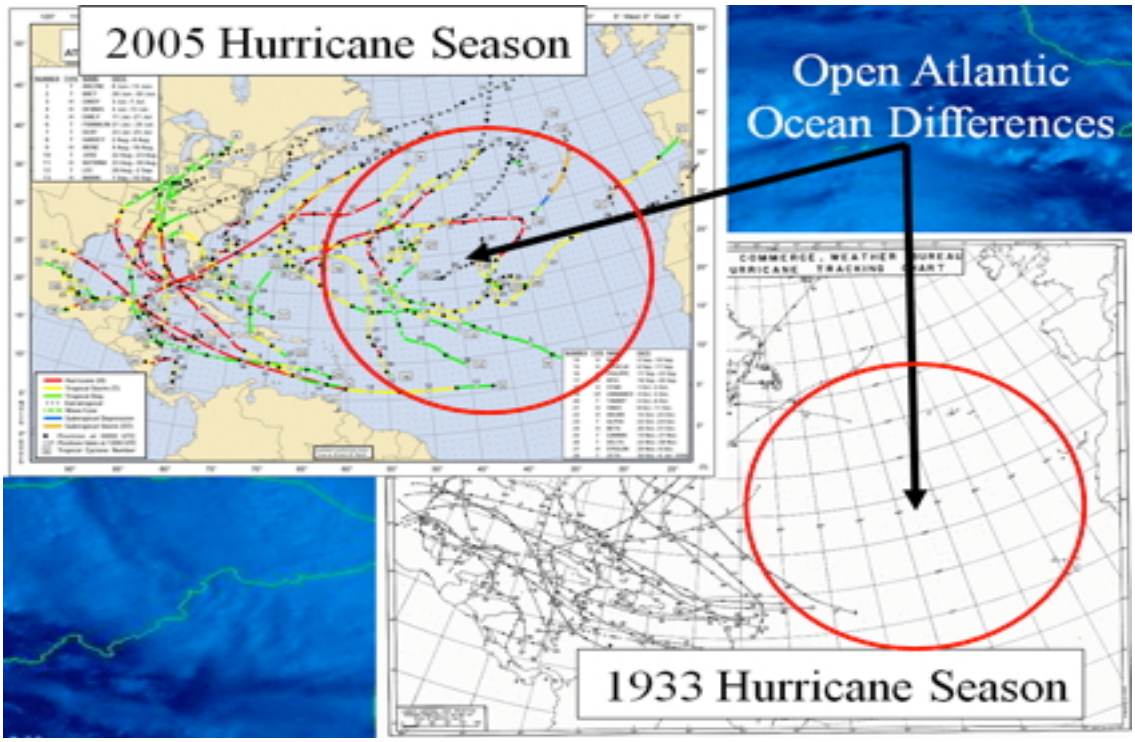
1886 came close with at least 10 hurricanes, 7 making landfall. 4 of the 1886 hurricanes were major hurricanes.



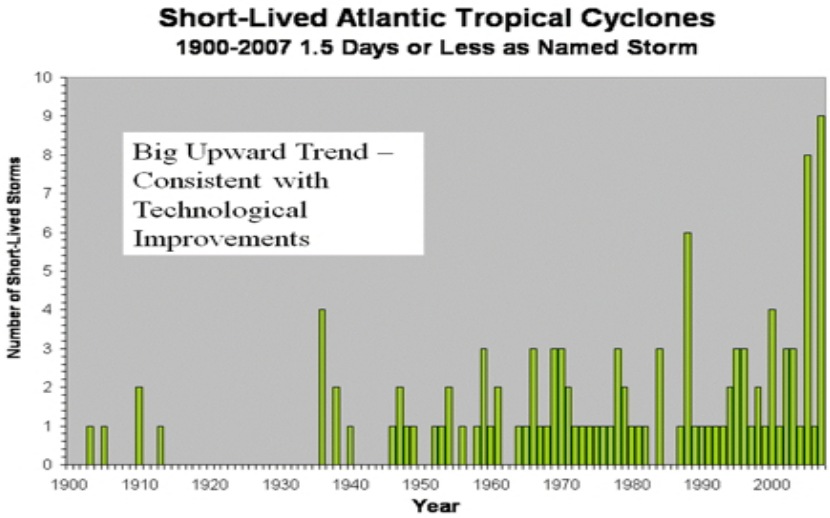
The Galveston Hurricane in1900 killed at least 8,000 people with some estimates as high as 12,000, making it the deadliest natural disaster in U.S. history.

Note that in the years up until the 1960s, the count of Atlantic storms away from land was unreliable as there were no satellites, no aircraft reconnaissance, no radar, no buoys and no automated weather stations.

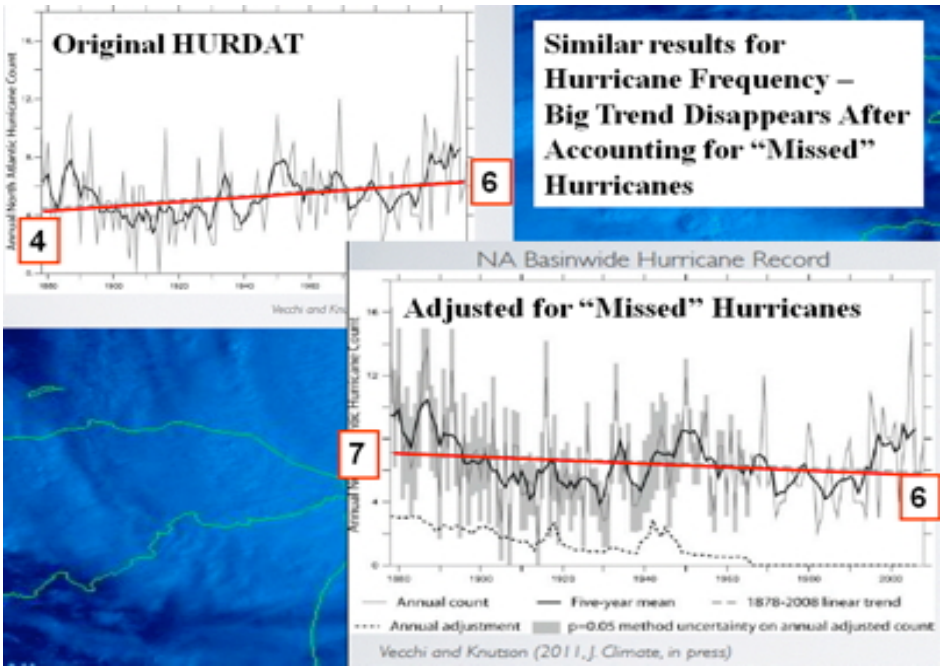
NOAA's Chris Landsea wrote: "Comparing the two busiest hurricane seasons on record - 2005 and 1933 - the difference across the ocean between those two years is apparent: there were several tropical storms and hurricanes in the eastern half of the North Atlantic in 2005, while in 1933 there were none. So either this huge gap in 1933 actually occurred, or there were tropical storms and hurricanes in the eastern half of the ocean, but they went unobserved. If one restricts the counting to those tropical storms and hurricanes that hit land in 2005, 17 of the 28 tropical storms and hurricanes made landfall. But in 1933, 19 of the 21 tropical storms and hurricanes in that season struck a coast. So by a metric of landfalling cyclones, 1933 was busier than 2005 and much of the long-term upward trend is removed".



Landsea reviewed the storms in 2007 and 2008 seasons and was able to identify at least six weak, short-lived tropical storms that would be very unlikely to have been "named" previously.

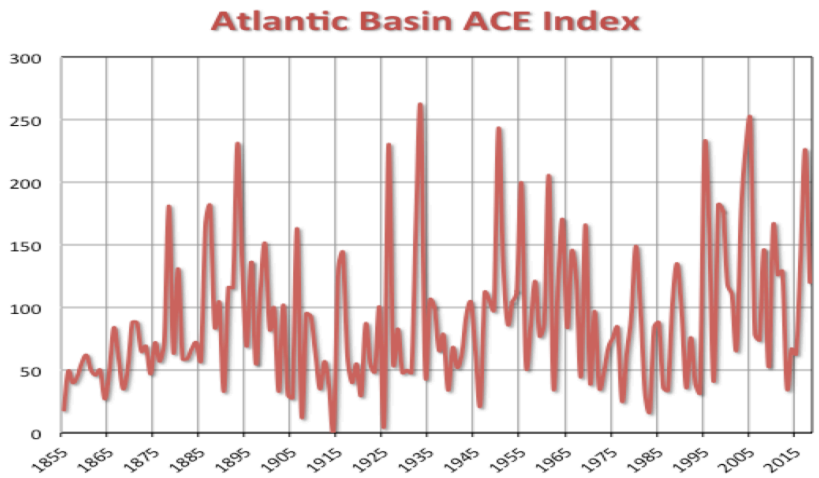


Landsea also speculated that even major hurricanes over the central or eastern North Atlantic - such as 2009's Hurricane Fred[27] and 2010's Hurricane Julia[28] - very likely would not have been "counted" as a major hurricane in the pre-satellite era of the 1940s to 1960s (and may have been even missed completely, given their locations).



ACE DATA BELIES THE CLAIM

The Accumulated Cyclone Energy (ACE) Index takes into account the number, duration and strength of all tropical storms in the year. It will be shown below that the pattern reflected in this data can be demonstrated to result from Natural Factors. The annualized Accumulated Cyclone Energy Index for the Atlantic shows a cyclical pattern behavior with spikes in 1893, 1926, 1933, 1950 then again in 1995, 2004, 2005 and 2017. Note again this data likely underestimates the early decades.



([UCO Tropical Meteorology Project])

2017 ranked 7th.

Rank	Season	ACE
1	1933	259
2	2005	250
3	1893	231
4	1926	230
5	1995	228
6	2004	227
7	2017	226
8	1950	211
9	1961	205
10	1998	182

Major Hurricanes

The Saffir–Simpson hurricane wind scale (SSHWS), formerly the Saffir–Simpson hurricane scale (SSHS), categorizes Western Hemisphere tropical cyclones by the intensities of their sustained winds. Category 3, 4 and 5 storms are called major hurricanes. Before 2010, both central pressure and wind had been used in categorizing hurricanes.

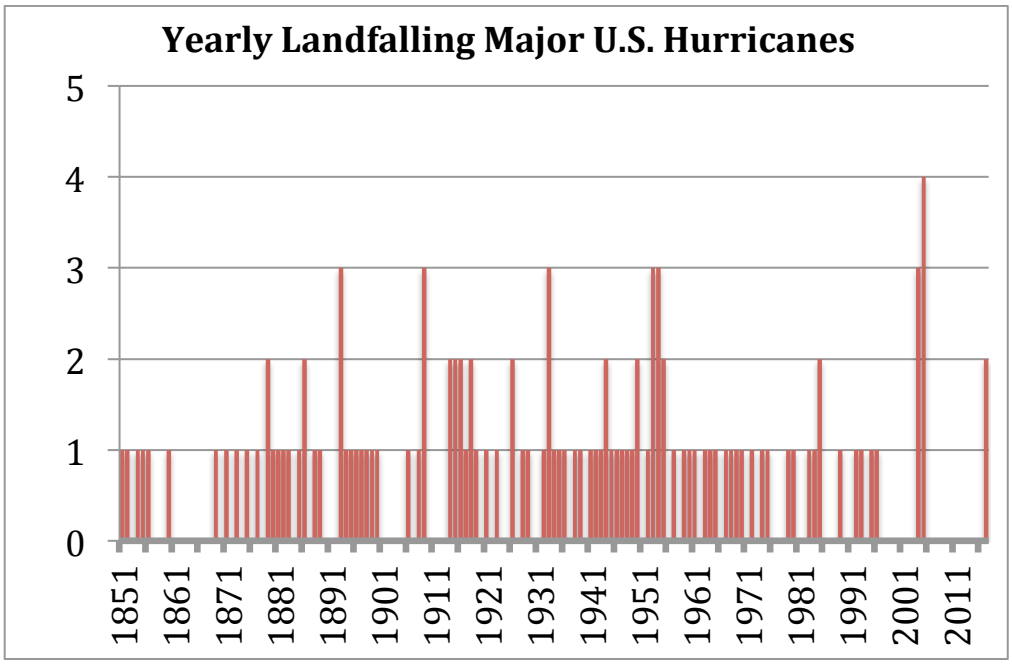
Saffir-Simpson Scale

Category	Wind Speeds
Category 5	More than 157 mph (more than 137 knots)
Category 4	130 to 156 mph (112 to 136 knots)
Category 3	111 to 129 mph (96 to 112 knots)
Category 2	96 to 110 mph (83 to 95 knots)
Category 1	74 to 95 mph (64 to 82 knots)
Tropical Storm	39 to 73 mph (34 to 63 knots)
Tropical Depression	Less than 38 mph (less than 33 knots)

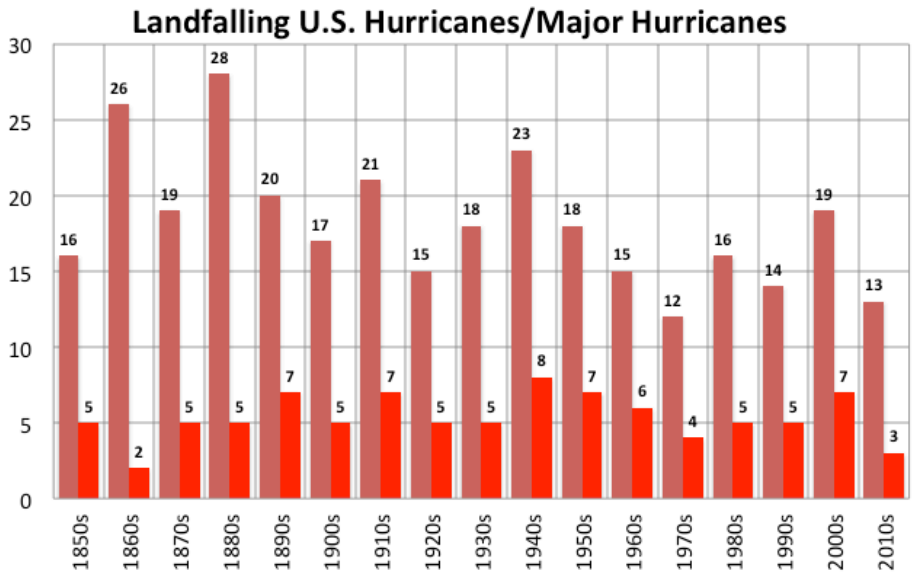
THE ACTIVE 2003 TO 2005 PERIOD THEN A RECORD LULL

Isabel in 2003, Charley, Frances, Ivan and Jeanne in 2004 and Dennis, Katrina, Rita and Wilma in 2005 all made landfall on the U.S. mainland. Emily in 2005 was another major hurricane but turned west into Mexico.

2005 holds the record for 5 category 4 or greater and 4 category 5 impact storms. At the time, some speculated this was the new norm for the Atlantic due to climate change. However, as shown below, after the active 2005 season and before the landfall of two major storms on the U.S. in 2017, the U.S. had gone 4324 days (just short of 12 years) without a major hurricane landfall, the longest such lull since the 8 years in the 1860s.



In fact, the number of U.S. landfalling hurricanes and major hurricanes have been on the decline since the late 1800s by decade. This decade was the second quietest for major landfalls behind only the 1860s, and second quietest for all landfalls behind only the 1970s.



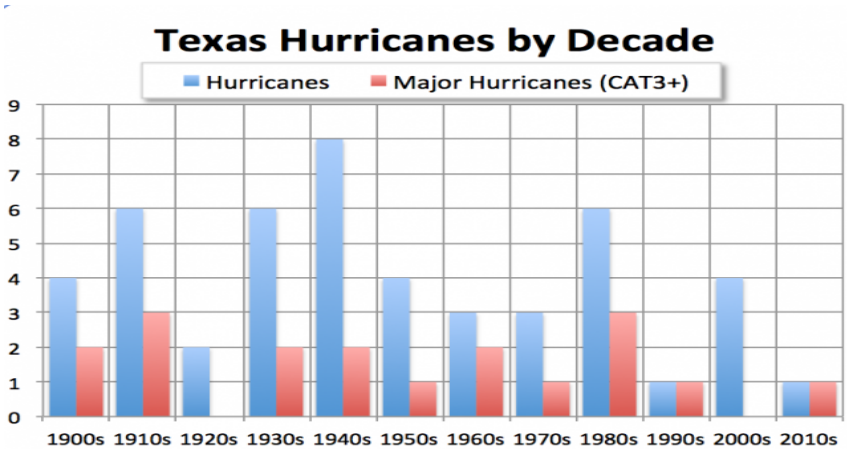
Source: AOML

THE 2017 SEASON

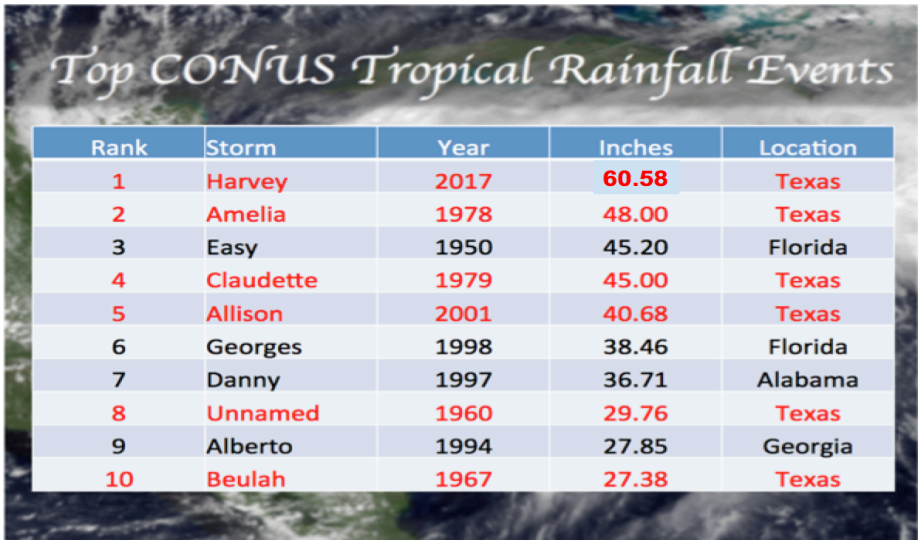
The 2017 hurricane season got started very early with Arlene in April but the real action held off until the last week of August when Hurricane Harvey flooded Texas and Louisiana.

Harvey

Harvey was the first hurricane to make landfall in Texas since Ike in 2008 and the first Category 4 hurricane in Texas since Hurricane Carla in 1961. Note that there has been no increase in Texas in either hurricanes or major hurricanes.



As for the heaviest rain record, Texas is the location where tropical storms often go to die dumping heavy rains for days. Six of the top ten tropical rain events had occurred in Texas as of 2017.



Rank	Storm	Year	Inches	Location
1	Harvey	2017	60.58	Texas
2	Amelia	1978	48.00	Texas
3	Easy	1950	45.20	Florida
4	Claudette	1979	45.00	Texas
5	Allison	2001	40.68	Texas
6	Georges	1998	38.46	Florida
7	Danny	1997	36.71	Alabama
8	Unnamed	1960	29.76	Texas
9	Alberto	1994	27.85	Georgia
10	Beulah	1967	27.38	Texas

Harvey meandered for several days drawing on a steady influx of Gulf moisture. The Houston area had between 30 and 45 inches generally but one gauge in the 154 rain gauge network in Harris County recorded over 50 inches and one to the east over 60 inches, breaking the record of 48 inches in Amelia in 1978.

Cliff Mass of the University of Washington in his blog did a careful analysis of the possible impacts of 'global warming 'on Hurricane Harvey. Based on the data, he concluded *"the results are clear: human-induced global warming played an inconsequential role in this disaster….There is no evidence that global warming is influencing Texas coastal precipitation in the long term and little evidence that warmer than normal temperatures had any real impact on the precipitation intensity from this storm…"The bottom line in this analysis is that both observations of the past decades and models looking forward to the future do not suggest that one can explain the heavy rains of Harvey by global warming, and folks that are suggesting it are poorly informing the public and decision makers."*

Irma
Irma in 2017, the 11th strongest Atlantic storm on record (using central pressure) had major impacts on Islands like Barbuda and St. Martin, the Virgin Islands, the Turks and Caicos and southern Bahamas. Then after crossing northern Cuba, it curled back into Florida. It was the first landfalling hurricane and major hurricane in Florida since Wilma in 2005. This also was also after a record lull – 4439 days. The previous record lull back to 1851 was 2191 days from 1979 to 1985.

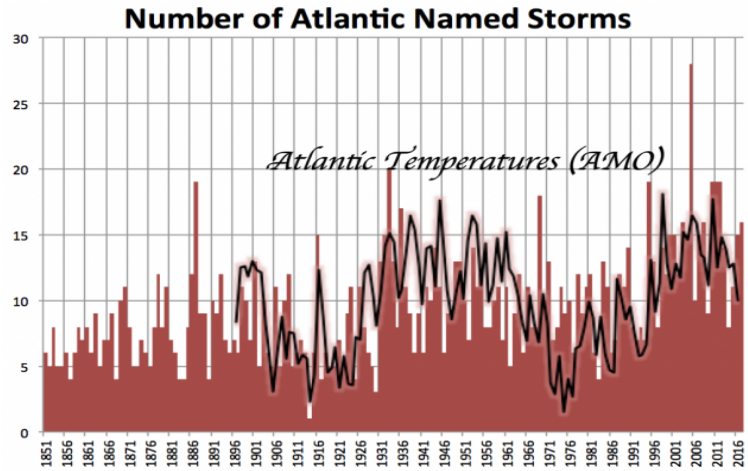
Maria
Maria was the third major Hurricane in 2017. It crossed the northern Leeward Islands and plowed through Puerto Rico, doing catastrophic damage to the island. In terms of intensity, Maria had the 9th lowest pressure ever recorded in the Atlantic Basin and Irma was tied for 11th. In 2005, three storms, Katrina, Rita and Wilma had lower pressure than any storm in 2017.

Nate
Hurricane Nate avoided another 'Katrina moment' for New Orleans but produced storm surge damage to southeast Louisiana, Mississippi, Alabama and the Florida Panhandle.

OCEAN TEMPERATURE AND PRESSURE PATTERNS

Tropical storm frequency and intensity are a function of ocean temperature and pressure patterns. The North Atlantic like the Pacific undergoes multi-decadal changes in ocean temperature and pressure patterns. It has long been known, when the Atlantic is in a warm Atlantic Multidecadal Oscillation (AMO) mode, there are more storms. Since 1995, when the current warm Atlantic mode began, the Atlantic Basin averaged 14.6 named storms per year, more than 5 more than the long-term 1851-2017 average.

See below the close fit of the AMO and the number of Atlantic Storms.



El Nino and La Nina affect Landfall

An important factor that affects whether hurricanes affect the United States is El Nino and La Nina. When El Ninos develop, more storms develop in the eastern and central Pacific threatening Mexico, Hawaii and sometimes in weakened forms Arizona and California.

These storms enhance high-level winds that cross into the Atlantic. These winds produce shear that disrupts developing storms causing them to weaken or dissipate and/or turn harmlessly north into the North Atlantic. Storms can still develop near the coast where the water is warm like in the Gulf and near the Gulf Stream off the southeast coast. See the Figure below.

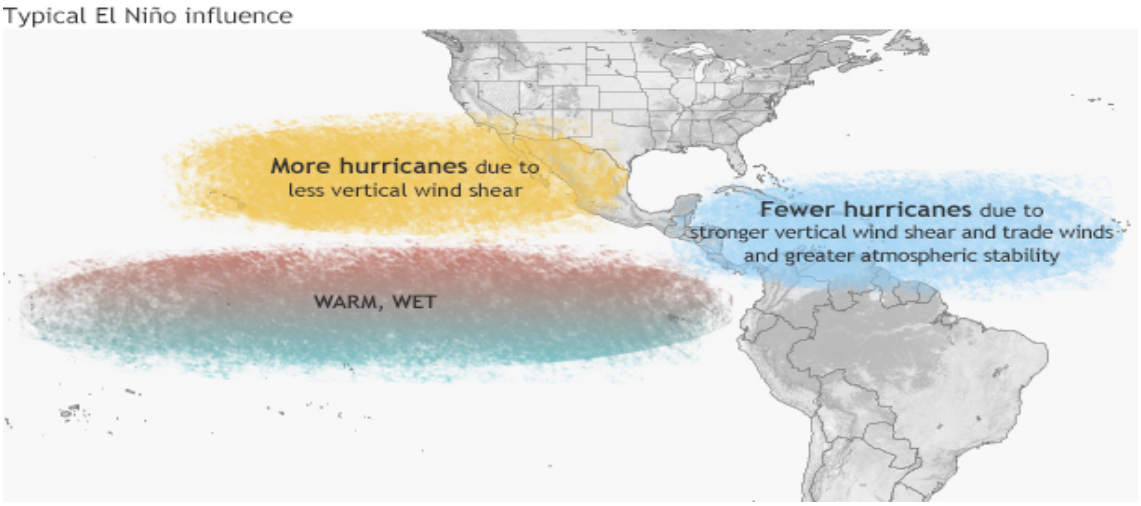


Image courtesy of climate.gov based on originals by Gerry Bell

When La Ninas develop there are usually fewer storms in the eastern Pacific and less shear to disrupt the Atlantic storms.

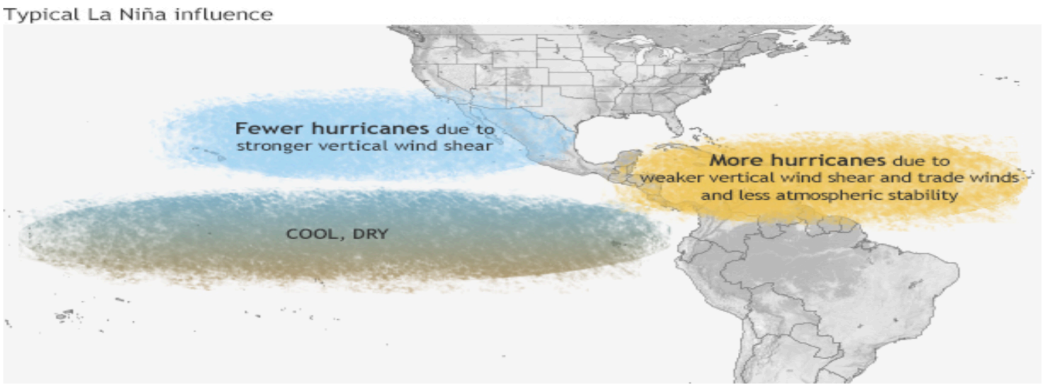
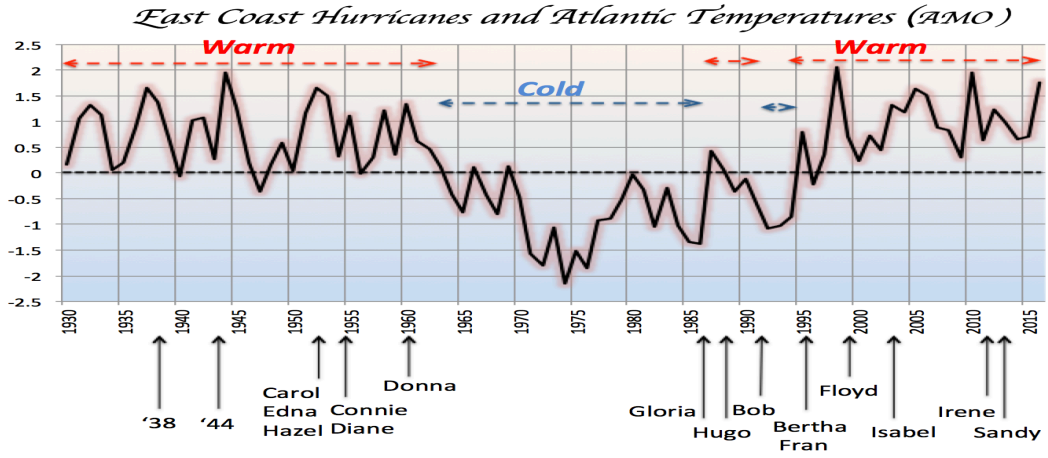


Image courtesy of climate.gov based on originals by Gerry Bell

In warm Atlantic years, that means trouble as the storms can track the entire Basin with more time to turn into major hurricanes. Even the east coast is more vulnerable to a landfalling hurricane when the Atlantic is warm. The U.S. had 8 high impact east coast hurricanes from 1938 to 1960 and 9 from 1988 to 2012 -during which time the AMO was typically in its warm state.



The last important La Nina stretch was in 2010/11 to 2011/12. The U.S. avoided a major hurricane hit, though major hurricanes at sea made final landfall in the NYC metro - Irene (as a tropical storm) in 2011 and Sandy in 2012 (as a post tropical cyclone). They caused massive flooding (from rains with Irene in upstate NY and Vermont and from a storm surge with Sandy in New York City and New Jersey).
The U.S. was still in the latest Atlantic warm period in 2017. That year, a spring attempt at an El Nino failed and La Nina like conditions

developed. Had El Nino succeeded, the U.S. may still have had Harvey, which developed near the Texas coast and Nate which came out of the bath water in the western Caribbean but maybe Irma and Maria would have been weakened or deflected. But with La Nina conditions developing, no shear and warm Atlantic water, the U.S. saw a return to big storms just as it saw in 2004 and 2005.

So, in a year like 2017, or back-to-back bad years like 2004 and 2005, Americans have to accept that is how the weather works. Permadroughts ended with record wet years for Texas and California this decade. The record nearly 12 year major hurricane 'drought' ended with 2017.

CLAIM: The hurricanes in 2017 were massive in size and stayed strong for a very long period fed by CO2 induced warming

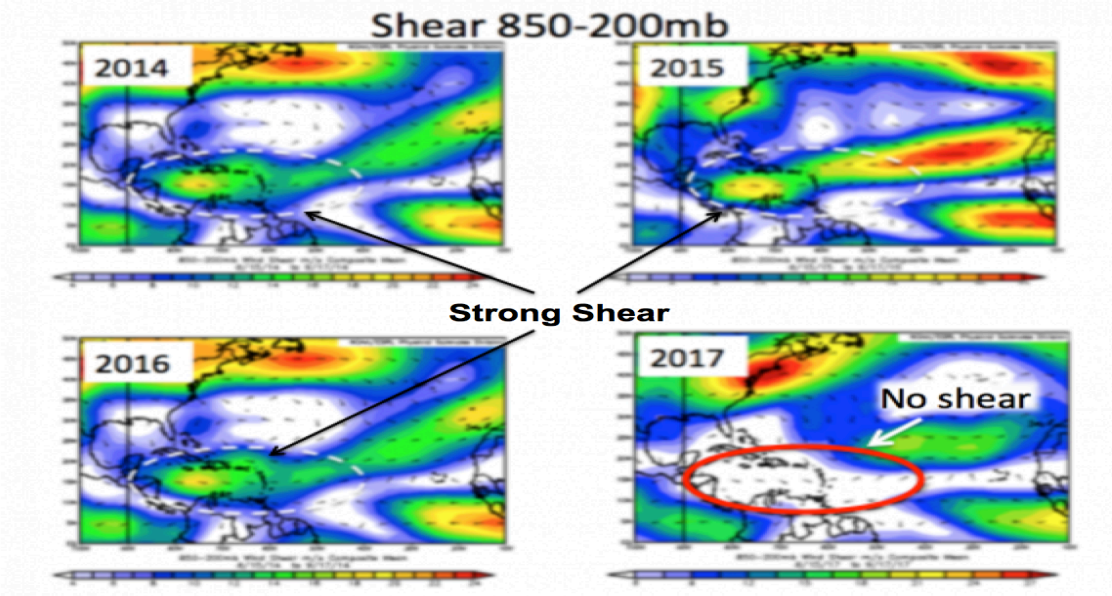
The strongest tropical system on record, Pacific super typhoon Tip in 1979 still holds the record for size (diameter of 1380 miles), strength (190 mph) and lowest pressure (870mb). Compare that storm with Harvey and Irma.

Source: Harris and Khandekar

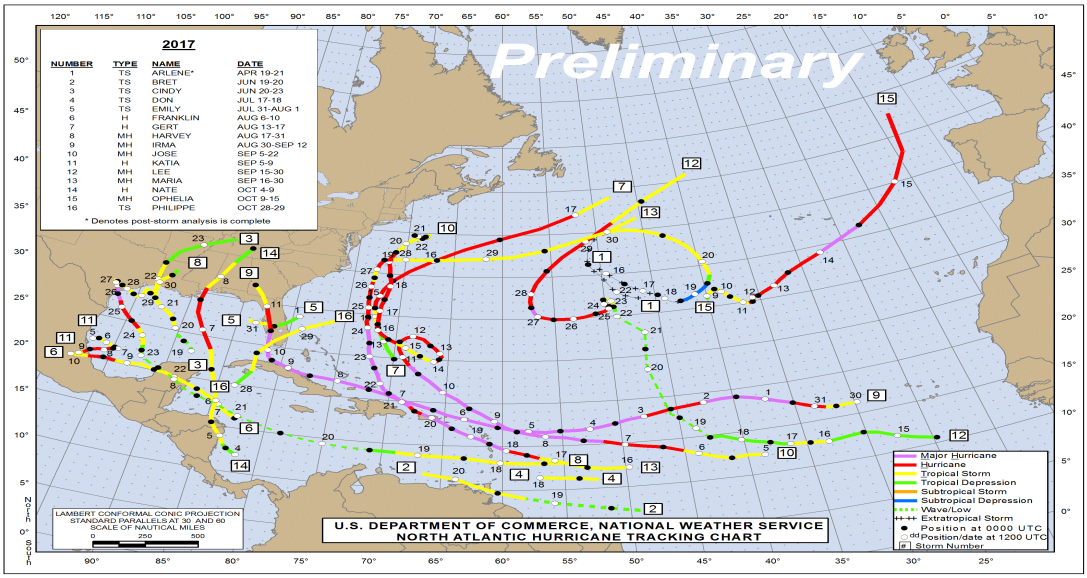
Note: Hurricane images reflect relative size only.

As discussed above, these storms maintained their intensity for a long time because in the warm Atlantic mode and with a developing La Nina,

atmospheric wind shear, which kept the storms at bay and short lived in 2014-2016, was absent.



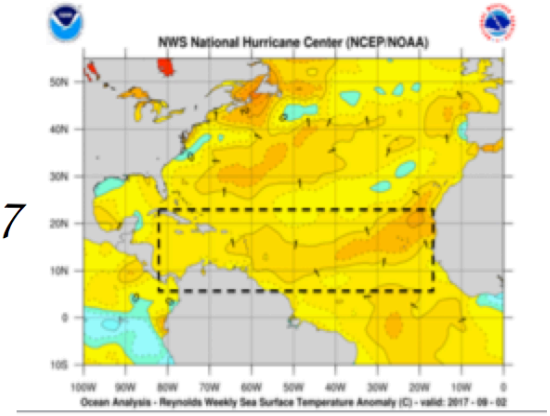
These storms also managed to navigate through the islands and avoid the mountainous islands like Hispaniola, which disrupts or even destroys many hurricanes. The purple segments along the tracks show the strongest storms were in this favorable environment.



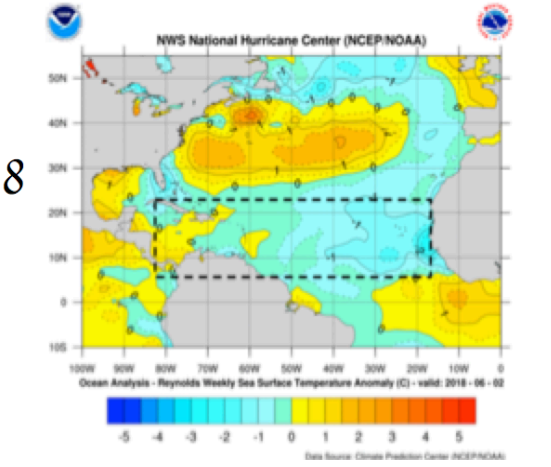
THE 2018 HURRICANE SEASON

The Atlantic where warm water in the tropical development regions of the subtropics were very warm in 2017, cooled in 2018. Water remained warm to the northwest (and by end of summer the Gulf and Caribbean). This pattern suggested less threat from the eastern Atlantic storm but potential trouble near the mainland.

June 2017



June 2018

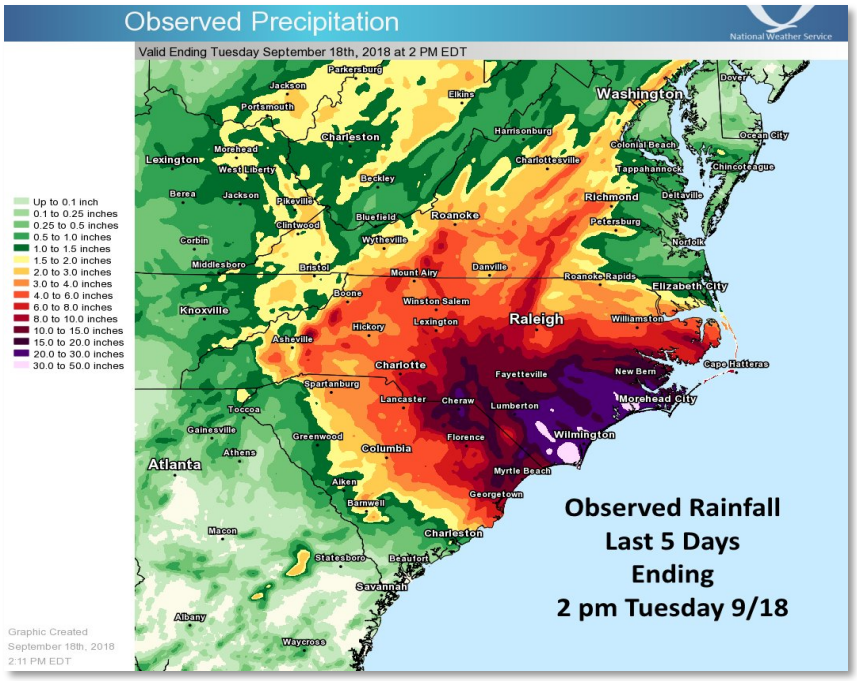


After sub-tropical storm Alberto made landfall on the Florida panhandle in late May, June was quiet before two storms, both of which briefly reached hurricane strength in July in the open Atlantic before dissipating.

August was below-average for the Atlantic basin with only two weak, high-latitude tropical storms and one tropical depression forming during the month. Based on a 30-year climatology (1981-2010), three named storms typically form in the basin in August, with one or two becoming hurricanes, and one major hurricane.
This was the first August since 1997 to have zero tropical storm formations in the Atlantic basin south of 30N.

In September, climatologically the busiest month for hurricane activity in the Atlantic, 5 storms were named as more favorable conditions developed. Two became hurricanes, only 1 storm, Florence became a major storm and had impact.

Florence became a major hurricane for almost 4 days before weakening and making landfall in North Carolina as a Category 1 storm. The main impact aside from significant storm surge locally 9 to 11 feet to the east of landfall, was the excessive rains and resulting major flooding.

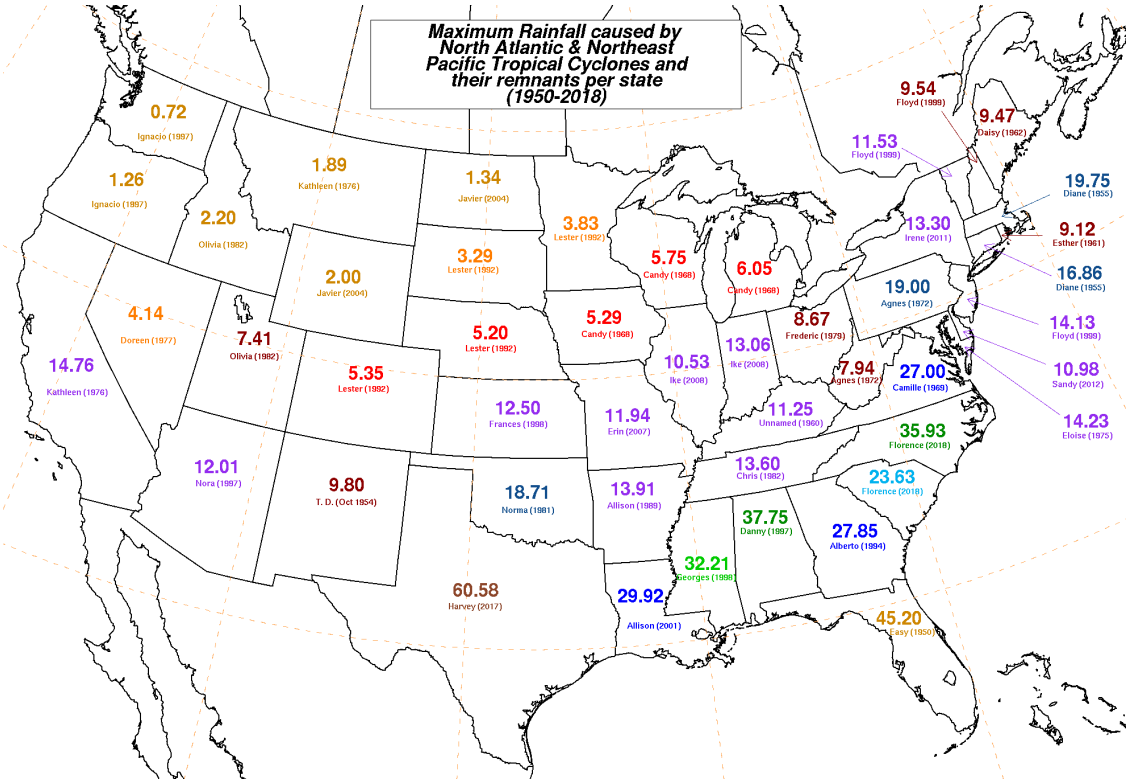


Several locations topped North Carolina's tropical cyclone rainfall record, including a report of 35.93 inches near Elizabethtown, North Carolina. (See Figure below.) The previous record was 24.06 inches from Hurricane Floyd in 1999.

Florence set a preliminary tropical cyclone rainfall record in South Carolina. Cheraw reported a storm total of 23.68 inches of rain. The previous record was 18.51 inches from Tropical Storm Jerry in 1995.

The rains were heavy because like Harvey in 2017, the storm moved inland and stalled as it became surrounded on three sides by high

pressure. Moisture kept feeding inland in bands around the weakening low pressure much like what was seen in Texas with Harvey last year.

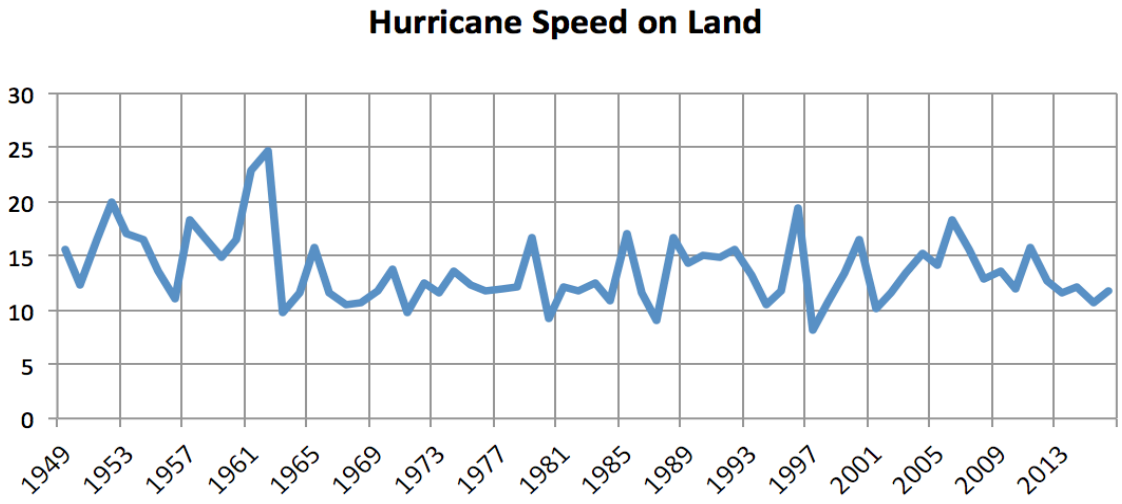


Florence is being compared to storms like Hazel in 1954, Hugo in 1989, Floyd in 1999 and Isabel in 2003. These storms brought much stronger winds and storm surge damage but the storms entered the U.S. with a stronger steering flow and the duration of the rains over any one area was measured in hours, not many days.

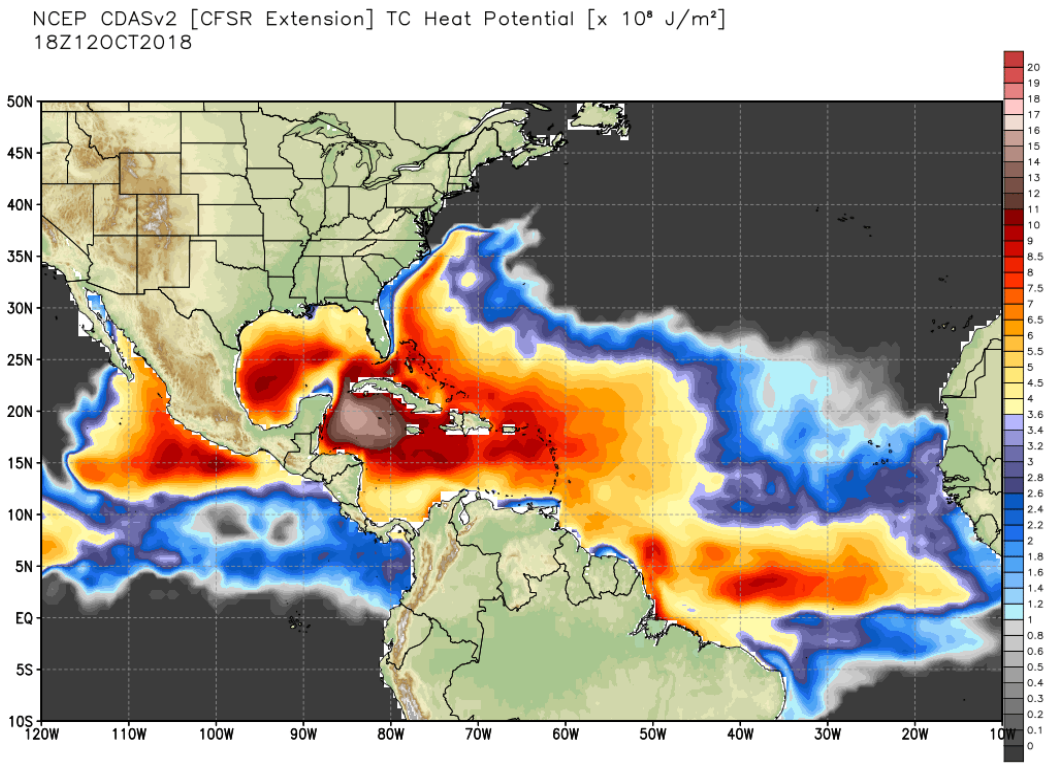
The claims that storms are moving slower over land due to global warming is not supported by the data. NOAA claimed speed of hurricanes crossing land has slowed by 17% since 1949 resulting in more rainfall.

However NOAA's actual data show no trend since 1963 after a two-year aberration in the early 1960s. A detailed statistical analysis shows no

statistically significant linear trend slope exists over the entire time period when the two early 1960s wild points are accounted for.



In October 2018, Michael developed in the warm Caribbean, where ocean heat content was highest.

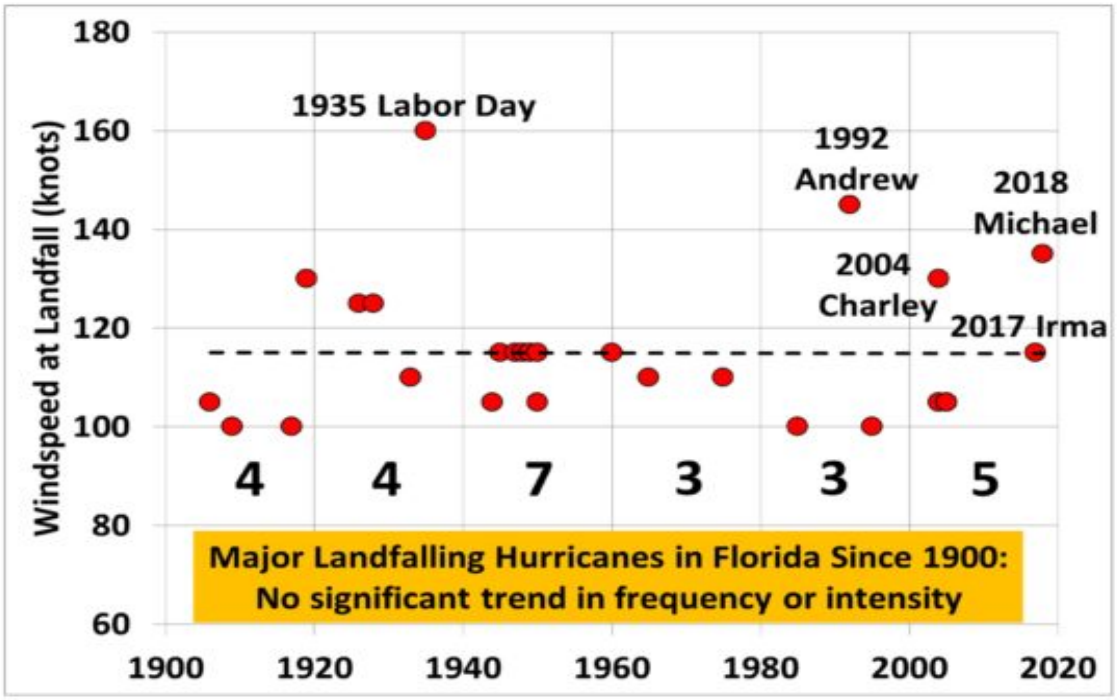


Michael was a typical end of season storm and had an upper level flow pattern very favorable for intensification and for landfall in the eastern Gulf. This despite the fact that many October storms are deflected into the open Atlantic. Michael had a reported pressure of 919 mb on landfall, the 20th lowest pressure for an Atlantic storm and third lowest pressure for a landfalling storm behind the 1935 Labor Day storm and Camille in 1969.

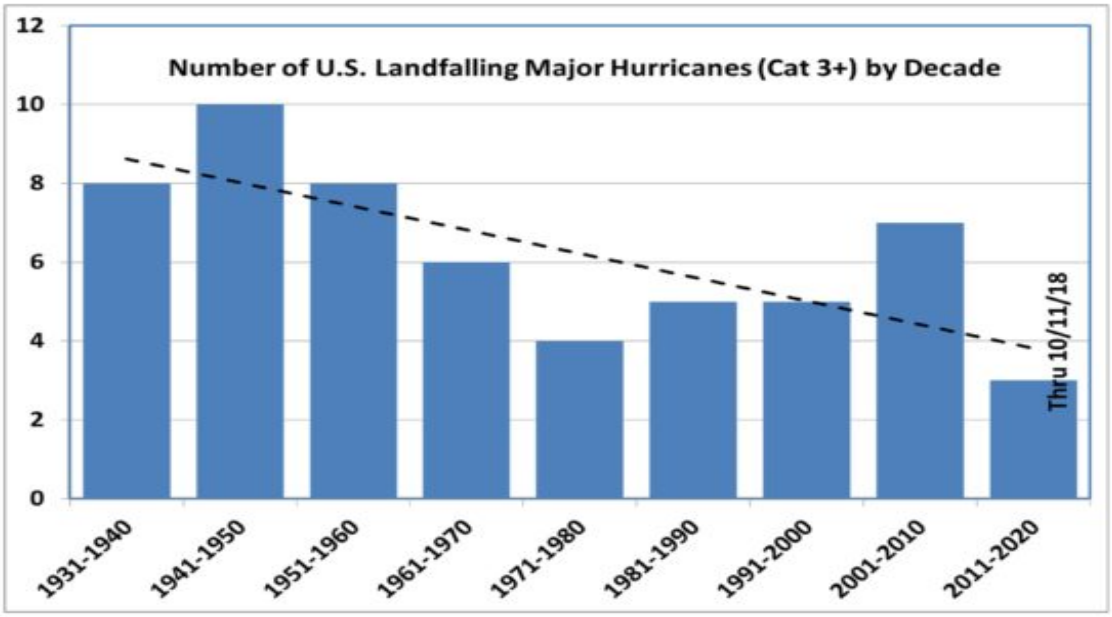
Dorian in 2019 was a CAT 5 storm when it sat for over a day leaving more than 70,000 people homeless on Grand Bahama and the Abaco Islands. It made landfall briefly on the outer bank of Cape Hatteras as a CAT1 hurricane

Strongest Atlantic Storms by Pressure		
Storm	Year	Pressure (mb)
Wilma	**2005**	**882**
Gilbert	1988	888
Labor Day	**1935**	**892**
Rita	2005	895
Allen	1980	899
Camille	1969	900
Katrina	2005	902
Mitch	1998	905
Dean	2007	905
Maria	2017	908
Cuba	1924	910
Ivan	2004	910
Dorian	**2019**	**910**
Janet	1955	914
Irma	**2017**	**914**
Cuba	1932	914
Isabel	2003	915
Opal	1995	916
Hugo	1989	918
Gloria	1985	919
Michael	**2018**	**919**
Hattie	1961	920
Floyd	1999	921
Andrew	**1992**	**922**
Bahamas	1929	924
David	1979	924
Igor	2010	924

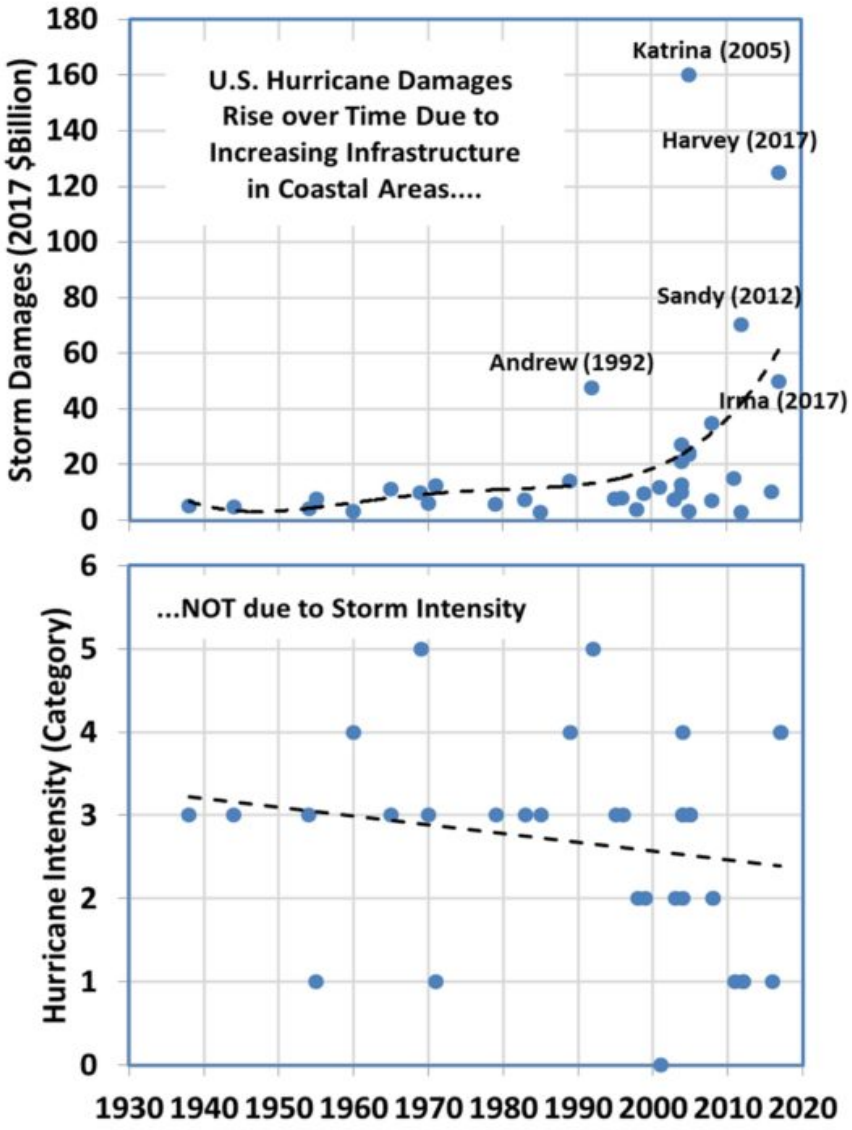
As indicated below, Dr. Roy Spencer showed there have been flat linear trends in hurricane frequency and intensity in Florida since 1900.



Dr. Spencer showed that contrary to popular perception, the number of major hurricanes making landfall in the U.S. has dropped by an average of more than 50% since the 1930s:



The most recent (2018) U.S. Government analysis of the 36 most costly hurricane disasters in U.S. history, showing that increasing damages are due to increasing population density and infrastructure vulnerability, not due to storm intensity.



The claim that the early landfall of Barry in 2019 was the result of global warming was rebutted here.

Dorian in early September of 2019 was a CAT 5 storm (tied for 10th lowest pressure) when it sat for over a day leaving more than 70,000 people homeless on Grand Bahama and the Abaco Islands. It made landfall briefly on the outer bank of Cape Hatteras as a CAT1 hurricane

Strongest Atlantic Storms by Pressure		
Storm	Year	Pressure (mb)
Wilma	**2005**	**882**
Gilbert	1988	888
Labor Day	**1935**	**892**
Rita	2005	895
Allen	1980	899
Camille	1969	900
Katrina	2005	902
Mitch	1998	905
Dean	2007	905
Maria	2017	908
Cuba	1924	910
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Dorian	**2019**	**910**
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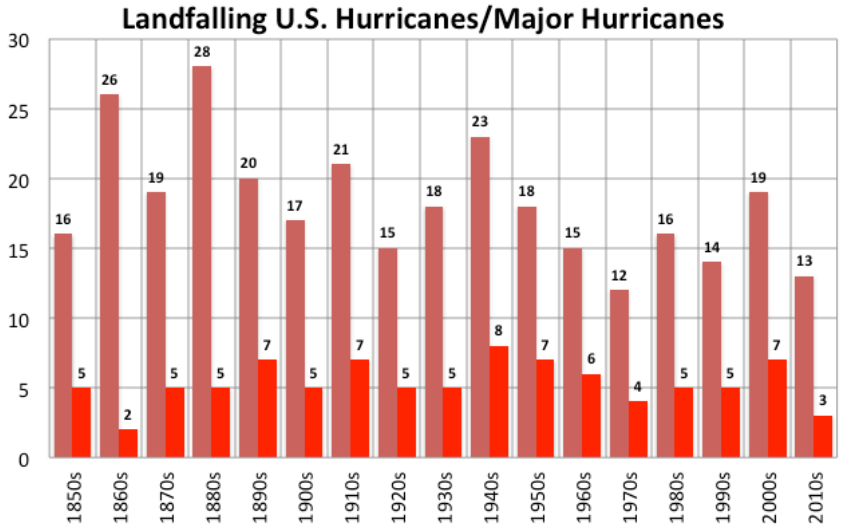
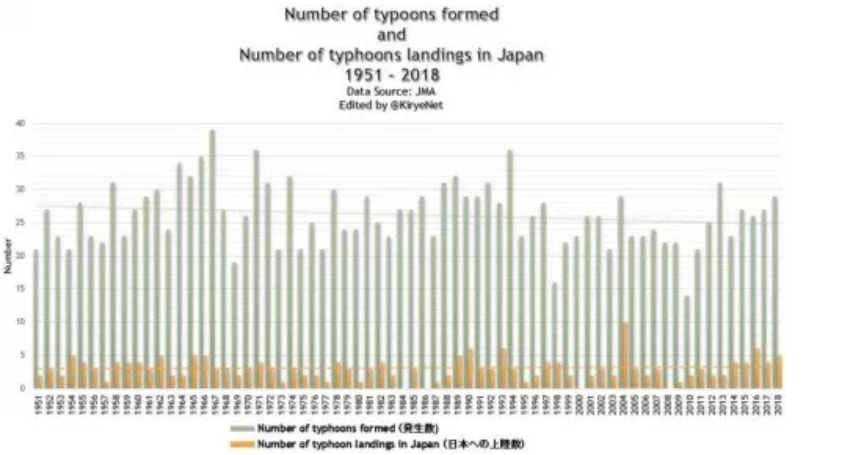
Despite Dorian and Humberto far out at sea, the season was a quiet one for the Atlantic Basin. In fact, the number of U.S. landfalling hurricanes and major hurricanes by decade have been on the decline since 1850. This decade was the second quietest for major landfalls behind only the 1860s, and second quietest for all landfalls behind only the 1970s.



Source: AOML

Finally halfway around the world where typhoons threaten each year, an analysis by the Japanese Meteorological Agency shows a cyclical pattern but with a slight downward trend in number of typhoons and no increase in landfalls.



The number of typhoons formed: JMA. Number of typhoons landings in Japan: JMA

2019 was unusually quiet in the western Pacific (74% of normal as of October 21).

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