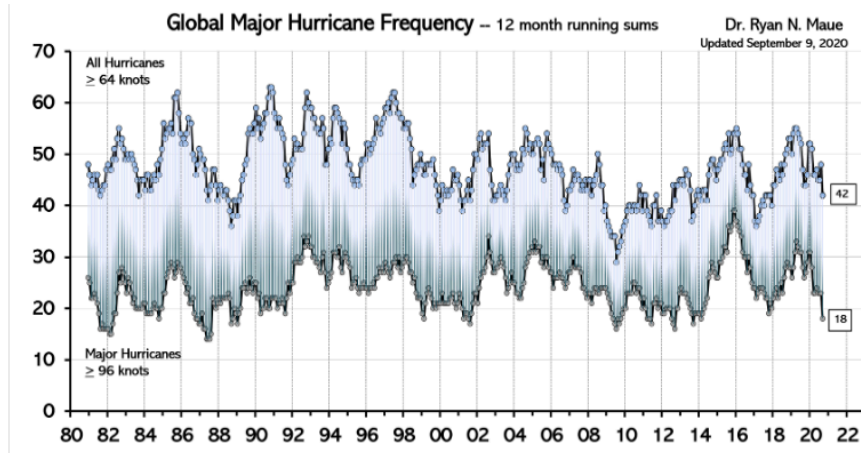


***Claim: Global warming is causing more hurricanes and stronger hurricanes***

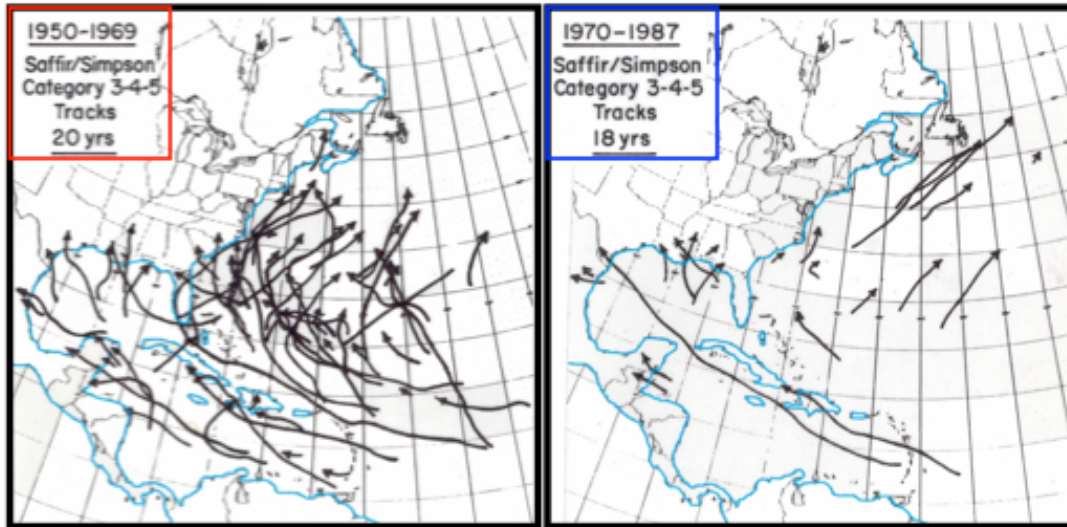
The long-term linear trend in the number and intensity of global hurricane activity has remained flat or even declined.



**Figure:** Global Hurricane Frequency (all & major) -- 12-month running sums. The top time series is the number of global tropical cyclones that reached at least hurricane-force (maximum lifetime wind speed exceeds 64-knots). The bottom time series is the number of global tropical cyclones that reached major hurricane strength (96-knots+). Adapted from Maue (2011) GRL.

Hurricane activity does vary year-to-year and over longer periods as short-term ocean cycles like El Nino/La Nina and multi-decadal cycles in the Pacific (PDO) and Atlantic (AMO) ocean temperature regimes favor changes in activity levels and some basins (West Pacific, East/Central Pacific or Atlantic) over others (Gray).

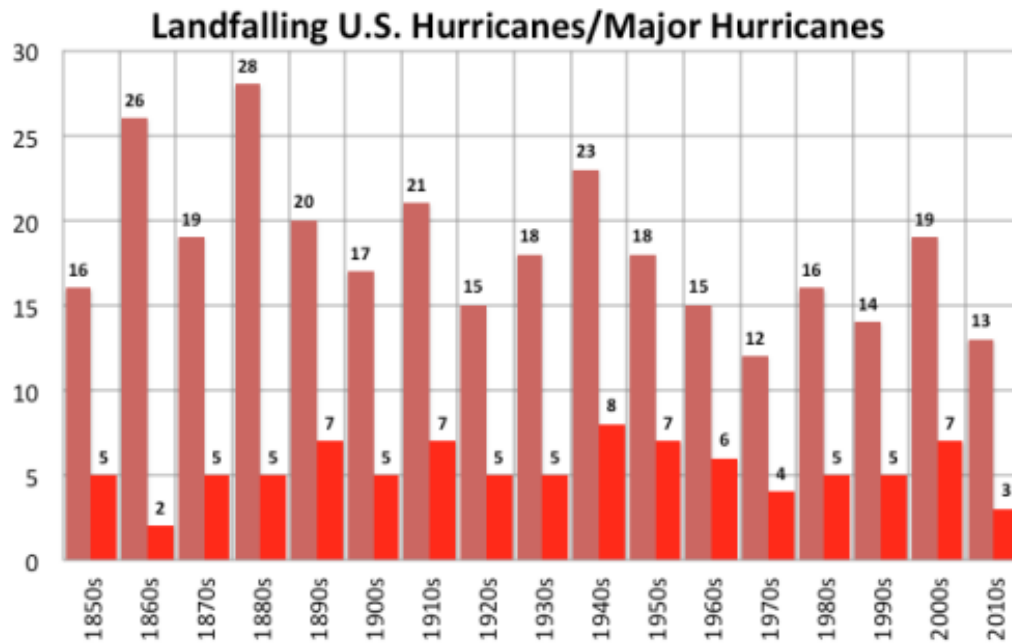
## TRACKS OF CATEGORY 3-4-5 HURRICANES



Credible data show this 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 actually 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).





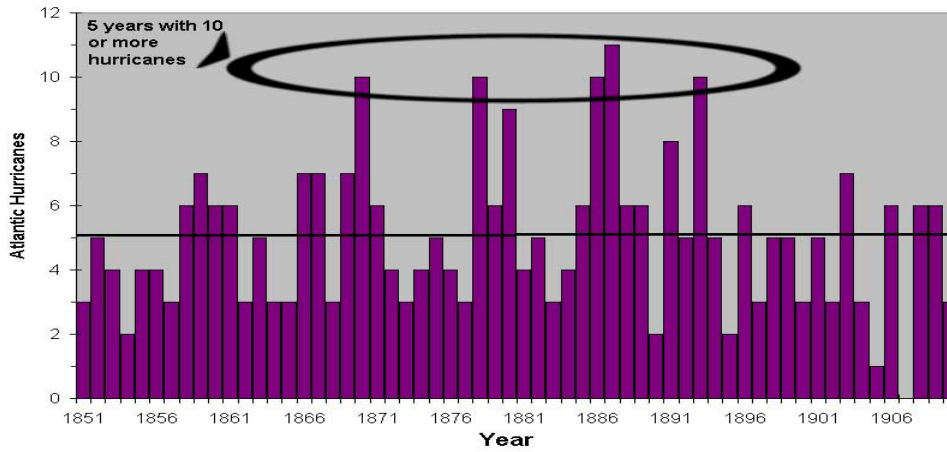
Source: AOML

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.

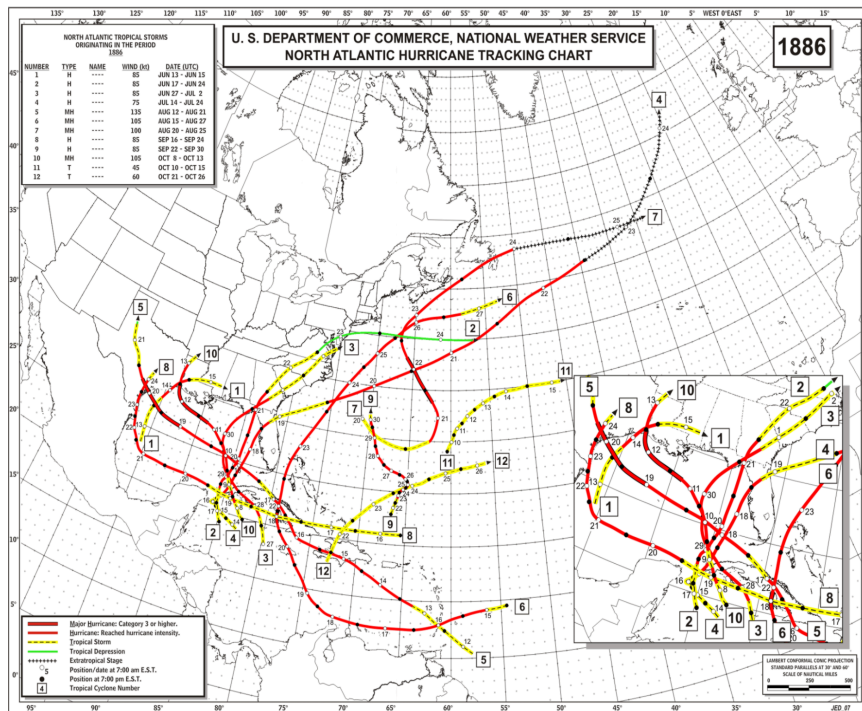
Great Colonial hurricanes in the northeast with storm surges up to 20 feet occurred in 1635 and 1675. A Katrina like storm made landfall in Louisiana in 1722 with major flooding and damage in Louisiana. The Great Chesapeake storm in 1769 like Isabel in 2003 brought major flooding to North Carolina and 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 period from the 1850s to 1910 was very active in the Gulf area.

## Atlantic Hurricanes 1851 to 1910



1886 had least 10 hurricanes, 7 making landfall (3 in Texas). 4 of the 1886 hurricanes were major hurricanes.



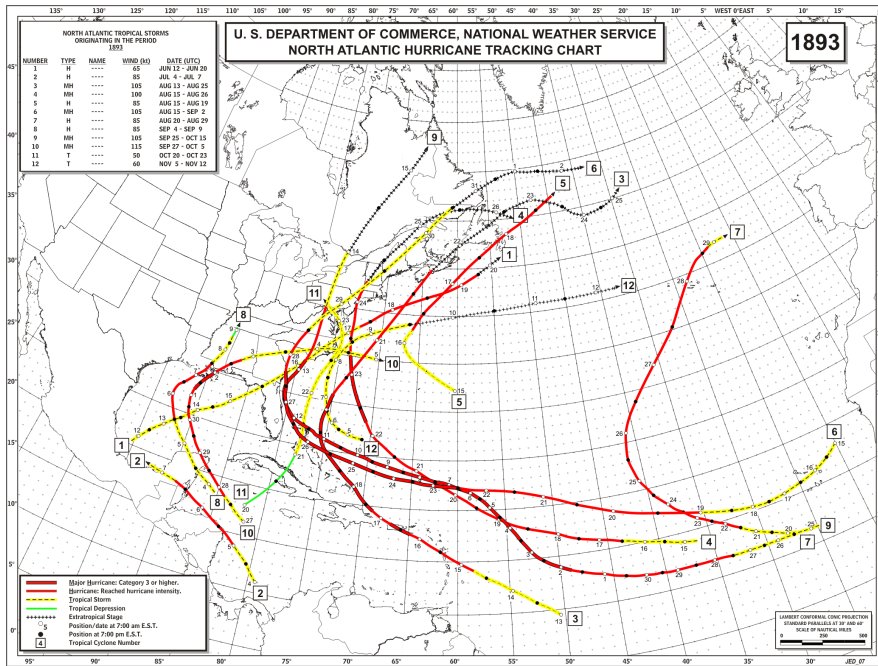
Dr. Neil Frank, longest serving Hurricane Center Director adds:

*“Without question the most reliable indicator of a trend in hurricane activity in the Atlantic is to focus on land falling major hurricanes (3-5) in the mainline U.S. I doubt if a major hurricane could have hit the U.S. in the 1800s without being noticed, while a minor hurricane in a remote area could have been undetected so it is important to concentrate on major hurricanes.*

*It is important to emphasize that the rainfall in a tropical system is not related to the intensity but depends on the forward speed of motion. In the case of Harvey, the weakening hurricane stalled over southeast Texas for three days.*

*Finally, as you know the most active hurricane season in the U.S. was 1886 when 7 hurricanes hit the Gulf coast. One of the major hurricanes in Texas destroyed Indianola on the south shore of Matagorda Bay. At one time there were around 20,000 people in the city before a prior major hurricane in 1875 did major damage. The only thing in Indianola today is a cemetery with numerous headstones with dates 1875 or 1886*

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.



The Galveston Hurricane in 1900 killed at least 8,000 people with some estimates as high as 12,000, making it the deadliest natural disaster in U.S. history.

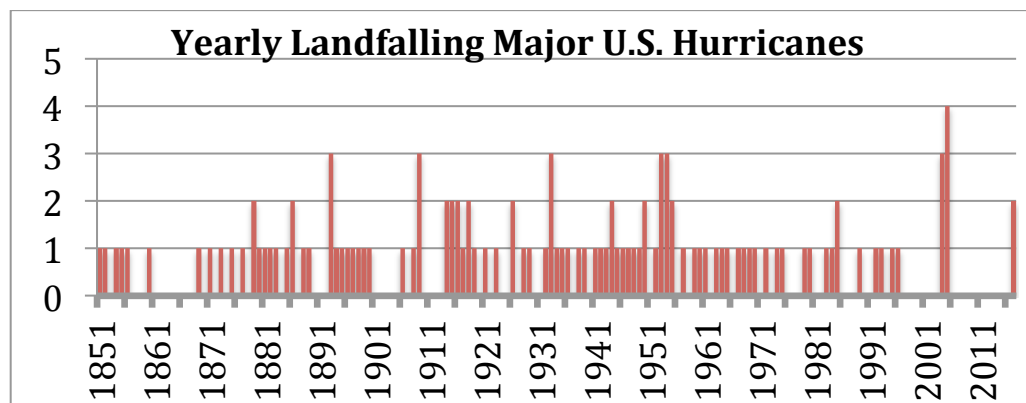
## Galveston Hurricane 1900



After decades of no impact storms, there were 8 major devastating storms on the east coast from 1938 to 1960 then a 28-year lull until Hugo began another active era of increased activity.

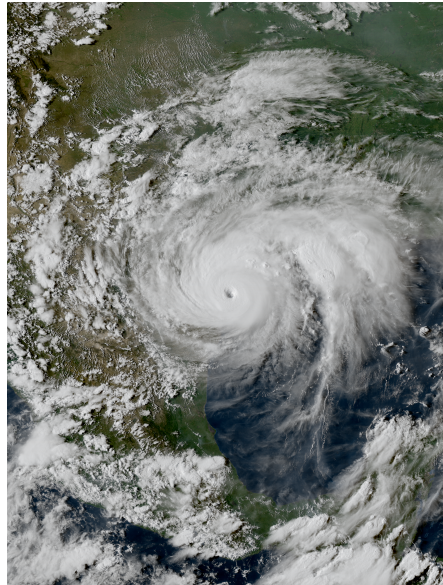
This century, Isabel in 2003, Charley, Frances, Ivan and Jeanne in 2004 and Dennis, Katrina, Rita and Wilma in 2005 all made landfall on the mainland. 2005 holds the record for 5 category 4 and 4 category 5 impact storms. At the time, some speculated this was the new norm for the Atlantic due to climate 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.

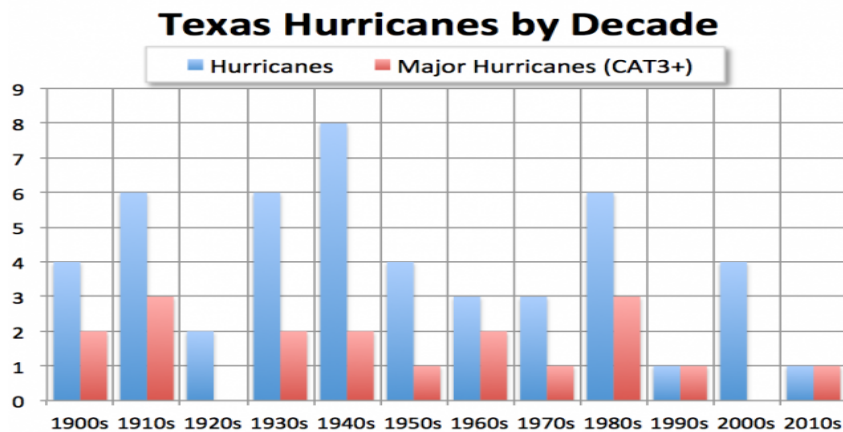


In 2017, Irma was the first landfalling hurricane and major hurricane in Florida since Wilma in 2005. This also was also after a record lull – 4439 days. The previous record lull back to 1851 was 2191 days from 1979 to 1985.

## HURRICANE HARVEY

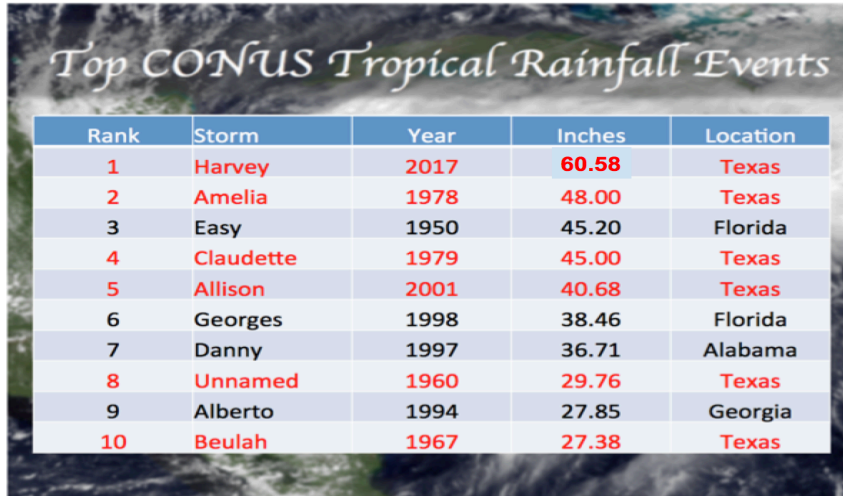


Harvey was the first hurricane to make landfall in Texas since Ike in 2008 and the first Category 4 hurricane in Texas since Hurricane Carla in 1961. Note that there has been no increase in Texas in either hurricanes or major hurricanes.

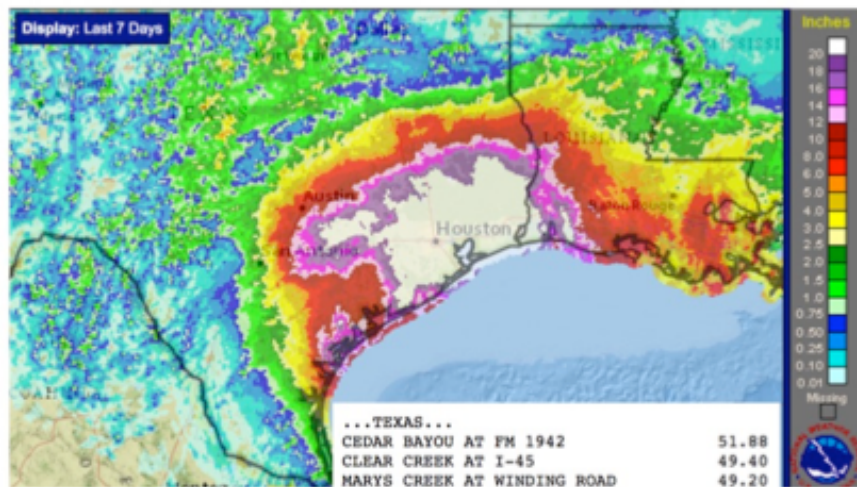


As for the heaviest rain record, Texas is the location where tropical storms often go to die dumping heavy rains for days. Six of the top ten tropical rain events for the mainland U.S. had occurred in Texas as of 2017.





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.

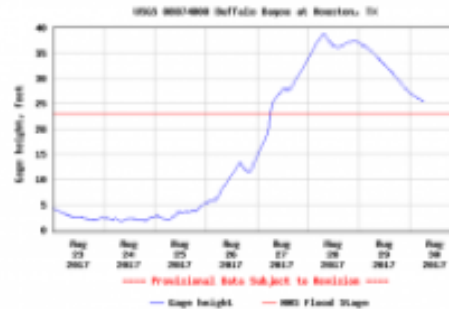


Harris County 171 rain gauges  
68 deaths

Southeast Texas is subject to extreme flooding even in other seasons.

In December of 1935 a massive flood occurred in the downtown area as the water level height measured at Buffalo Bayou in Houston topped out at 54.4 feet.

The Buffalo Bayou gauge topped out with Harvey at around 39 feet on the 28<sup>th</sup>.



[Cliff Mass](#) of the University of Washington did a careful analysis of the possible impacts of 'global warming' on Hurricane Harvey.

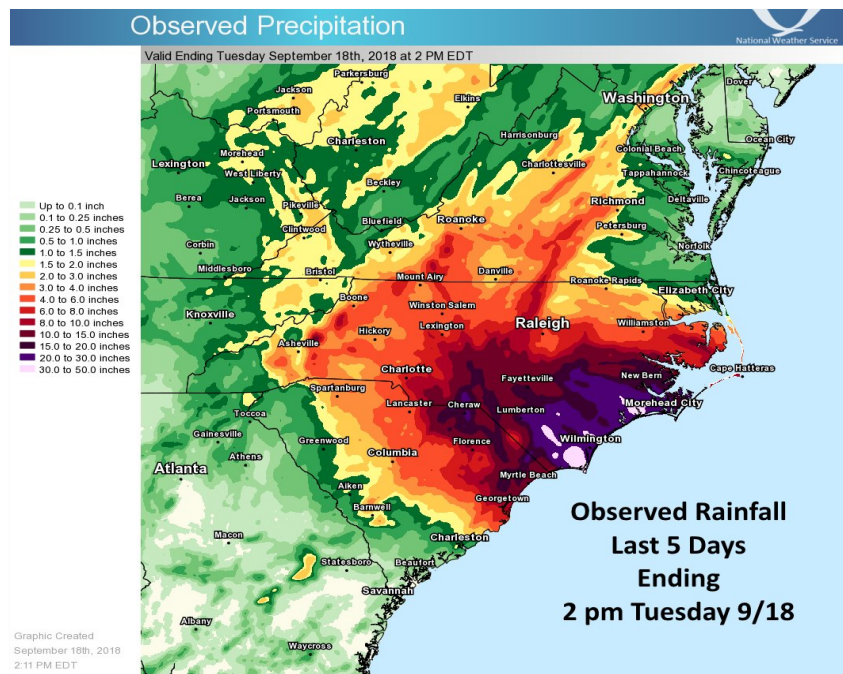
Based on the data, he concluded *"the results are clear: human-induced global warming played an inconsequential role in this disaster.... There is no evidence that global warming is influencing Texas coastal precipitation in the long term and little evidence that warmer than normal temperatures had any 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."

The heavy rains associated with slow moving Harvey and later in 2018 with Florence led to claims that slow movement was related to climate change.

## THE 2018 SEASON

After a slow start, the 2018 season came alive 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.

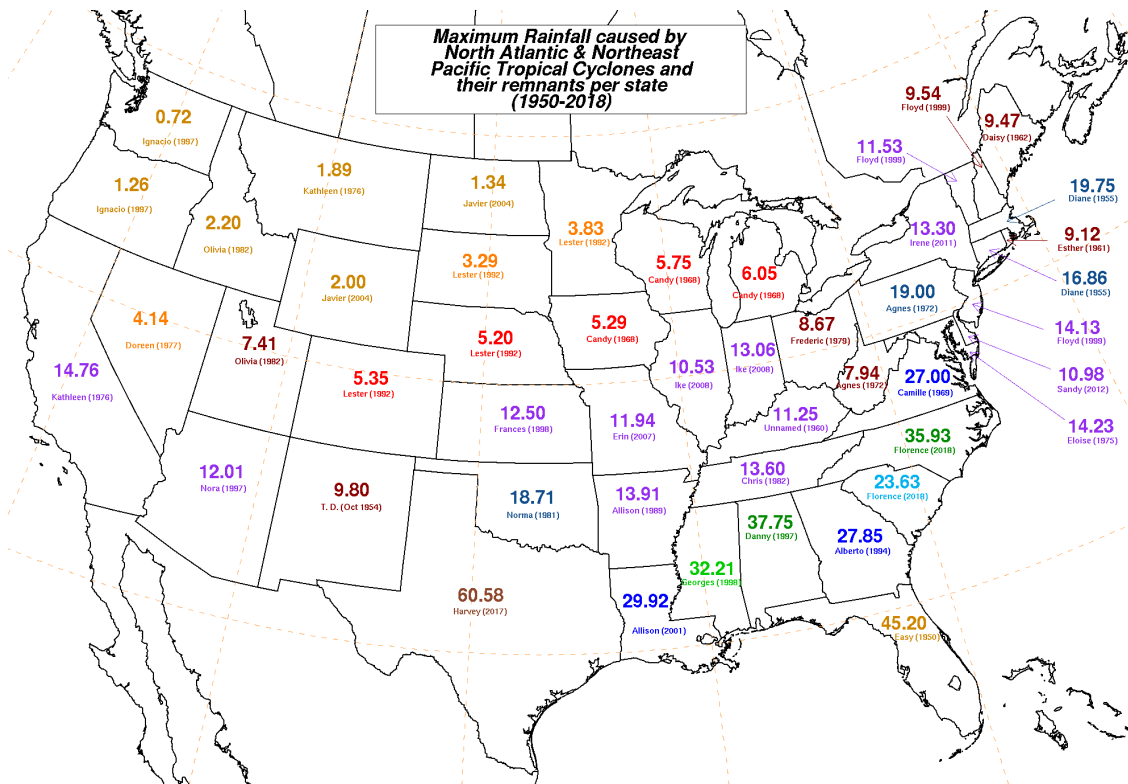
Florence became a major hurricane for almost 4 days before weakening and making landfall in North Carolina as a Category 1 storm. The main impact aside from significant storm surge locally 9 to 11 feet to the east of landfall, was the excessive rains and resulting major flooding.



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.



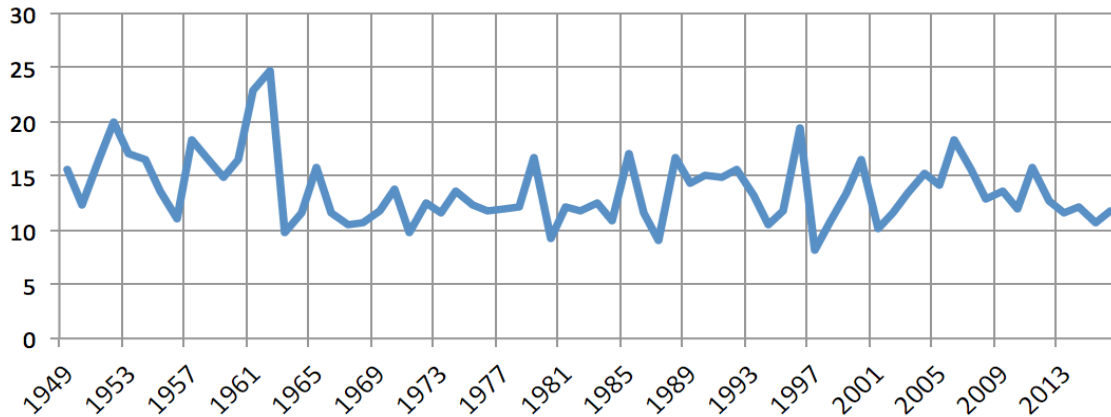
Florence was compared to storms like Hazel in 1954, Hugo in 1989, Floyd in 1999 and Isabel in 2003. These storms brought much stronger winds and storm surge damage but the storms entered the U.S. with a stronger steering flow and the duration of the rains over any one area was measured in hours, not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



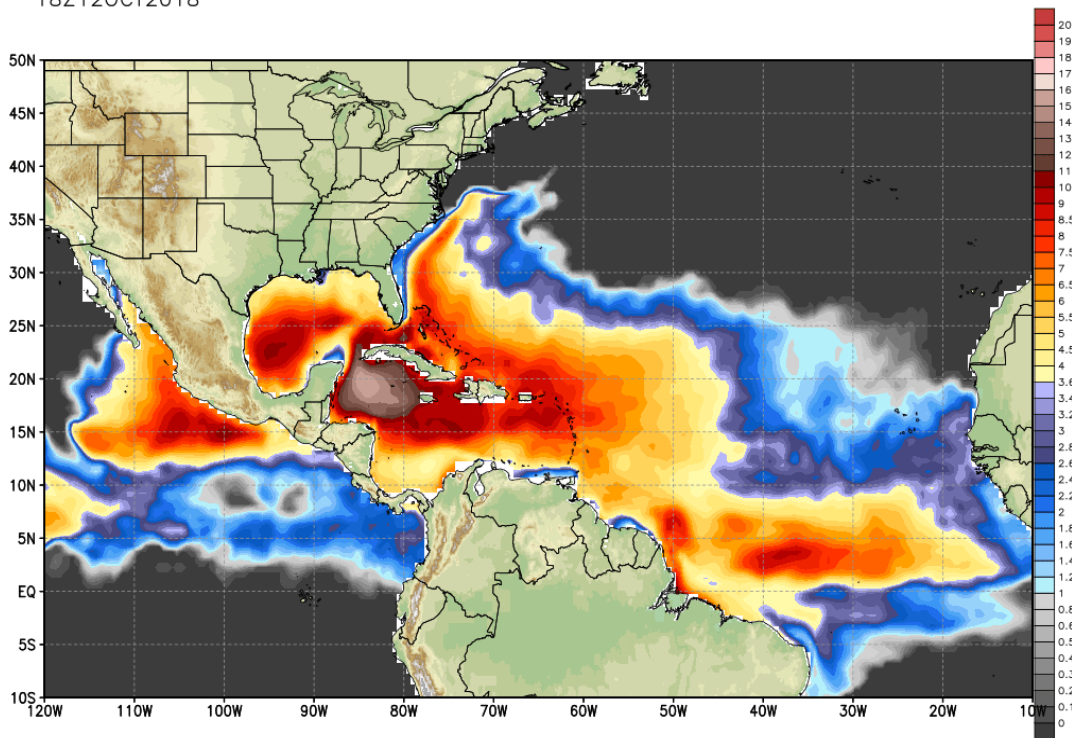
However NOAA's actual data show no trend since 1963 after a two-year aberration in the early 1960s. A detailed statistical analysis shows no statistically significant linear trend slope exists over the entire time period when the two early 1960s wild points are accounted for.

### Hurricane Speed on Land



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

NCEP CDASv2 [CFSR Extension] TC Heat Potential [ $\times 10^8 \text{ J/m}^2$ ]  
18Z12OCT2018



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 was true despite the fact that many October storms are deflected into the open Atlantic. Michael had a reported pressure of 919 mb on landfall, the 20<sup>th</sup> 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)
<b>Wilma</b>	<b>2005</b>	<b>882</b>
Gilbert	1988	888
<b>Labor Day</b>	<b>1935</b>	<b>892</b>
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
<b>Dorian</b>	<b>2019</b>	<b>910</b>
Janet	1955	914
<b>Irma</b>	<b>2017</b>	<b>914</b>
Cuba	1932	914
Isabel	2003	915
Opal	1995	916
Hugo	1989	918
Gloria	1985	919
<b>Michael</b>	<b>2018</b>	<b>919</b>
Hattie	1961	920
Floyd	1999	921
<b>Andrew</b>	<b>1992</b>	<b>922</b>
Bahamas	1929	924
David	1979	924
Igor	2010	924



Michael whose tight core winds did major damage on a portion of the Florida panhandle had the 20<sup>th</sup> 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 2020, Laura, a CAT 4 storm with 938mb pressure came ashore near where Rita did in 2005 with a similar central pressure. But both were less intense than Katrina that flooded New Orleans in 2005. Claims that Laura was the most intense storm to make landfall in the region were made despite the fact central pressure of 938mb did not even come close to making the list of the top 27 Atlantic Basin hurricanes.

## INCREASING DAMAGE STUDIES

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.*

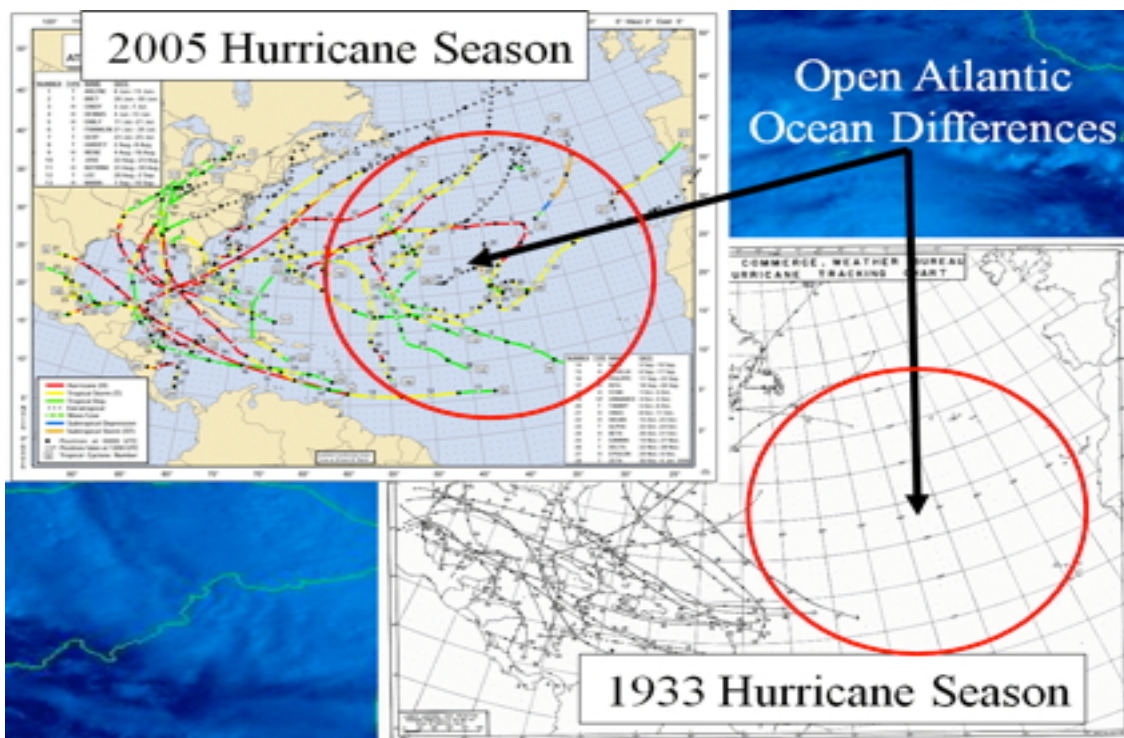
*Certainly, the U.S. hurricane damages from 1996 to 2005 were quite high, but now it is evident that these were quite similar to the decade of 1926 to 1935. So, after straightforward consideration of the non-meteorological factors of inflation, wealth increases, and population change, there remains no 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.”*

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.

## TRYING TO COMPARE HURRICANE COUNTS BEFORE THE SATELLITE ERA

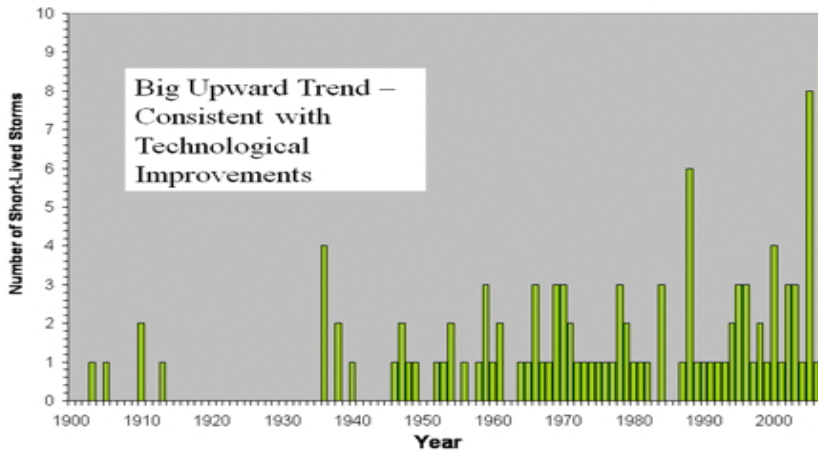
NOAA's [Chris Landsea](#) wrote: *"Comparing the two busiest hurricane seasons on record - 2005 and 1933 - the difference across the ocean between those two years is apparent: there were several tropical storms and hurricanes in the eastern half of the North Atlantic in 2005, while in 1933 there were 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".*

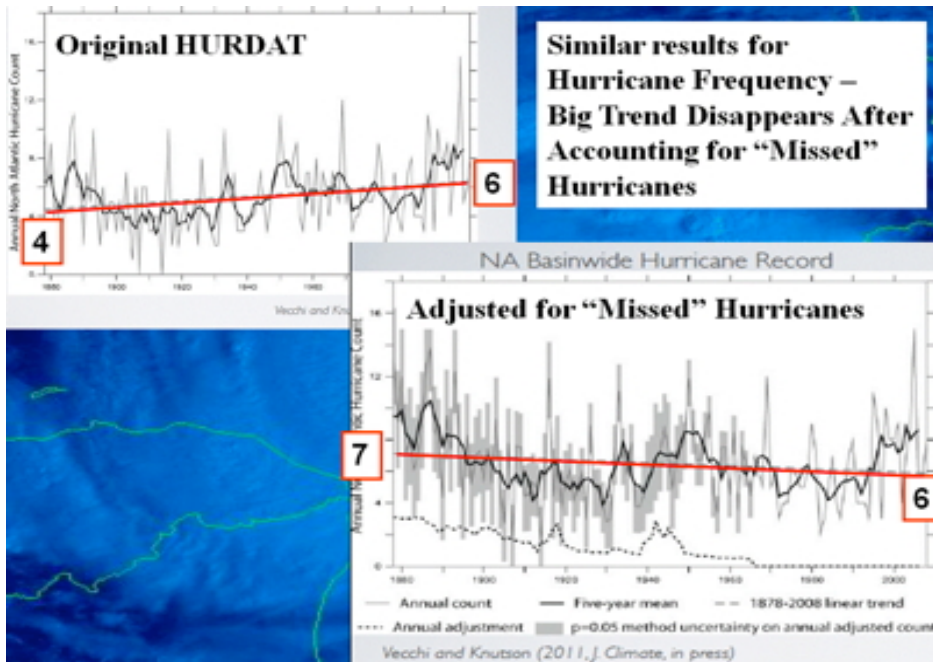


Landsea reviewed the storms in 2007 and 2008 seasons and was able to identify at least six weak, short-lived tropical storms that would be very unlikely to have been "named" previously.

**Short-Lived Atlantic Tropical Cyclones  
1900-2007 1.5 Days or Less as Named Storm**

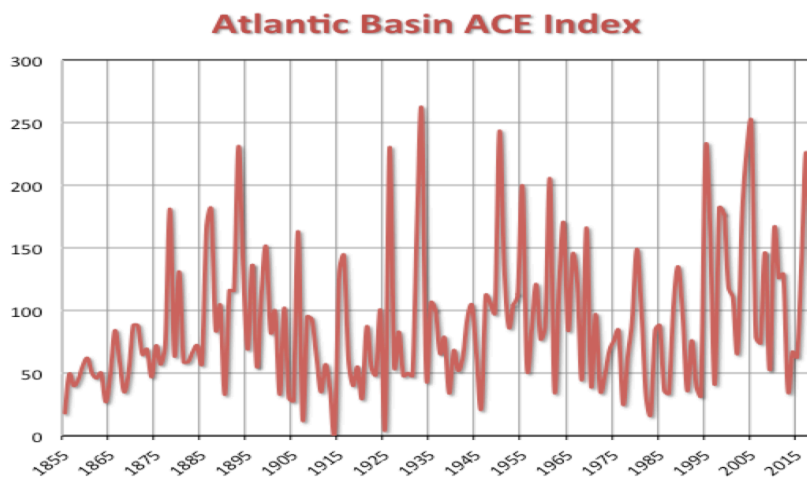


Landsea also speculated that even major hurricanes over the central or eastern North Atlantic - such as 2009's Hurricane Fred<sup>27</sup> and 2010's Hurricane Julia<sup>28</sup> - very likely would not have been "counted" as a major hurricane in the pre-satellite era of the 1940s to 1960s (and may have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



## ACE DATA ALSO 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 and 1950 then again in 1995, 2004, 2005 and 2017. Note again this data likely underestimates the early decades.



[\(UCO Tropical Meteorology Project\)](#)

2017 ranked 7<sup>th</sup>.

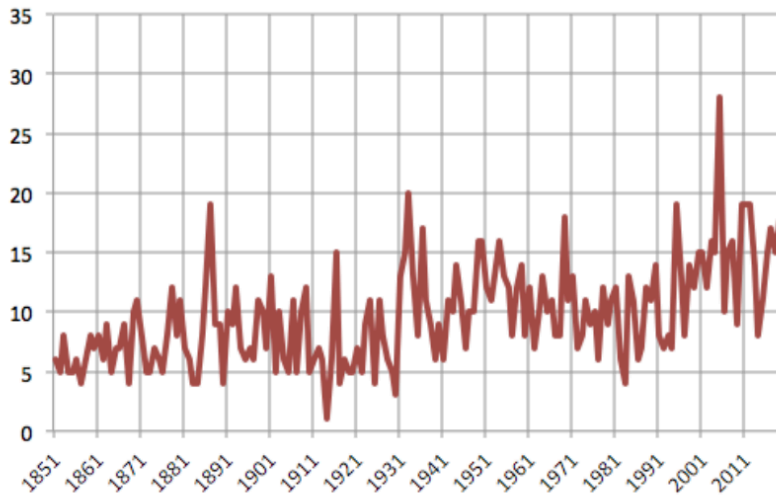
Rank	Season	ACE
1	1933	259
2	2005	250
3	1893	231
4	1926	230
5	1995	228
6	2004	227
7	2017	226
8	1950	211
9	1961	205
10	1998	182

## THE ODD DIVERGENCE GROWS IN 2020

2020 had been a hyperactive season with a warm Atlantic and a developing La Nina in the Pacific that limits shear in the Atlantic, allowing more waves to develop.

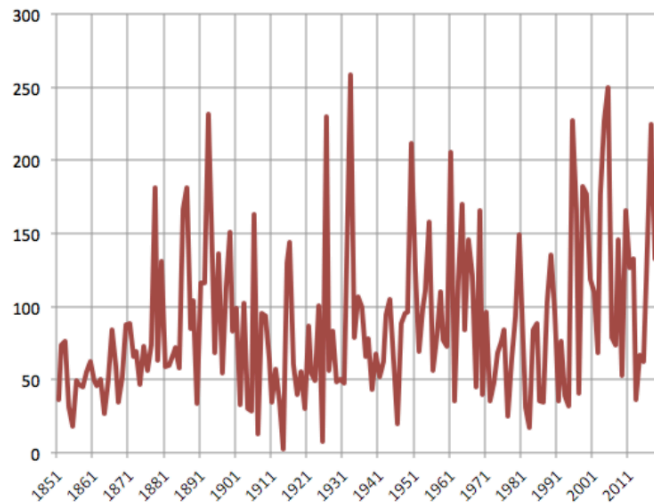
30 named storms were tallied for the Atlantic.

### Number Named Storms North Atlantic



But most remained weak or short lived and the cyclone energy is only slightly above the long-term average. See where the ACE ended.

### North Atlantic ACE Index Annual



Globally the ACE was only 78% of normal as both the eastern and western Pacific Basins were much quieter than normal. The trend in the western Pacific is down since 1951

