September 2023

CliSciPol

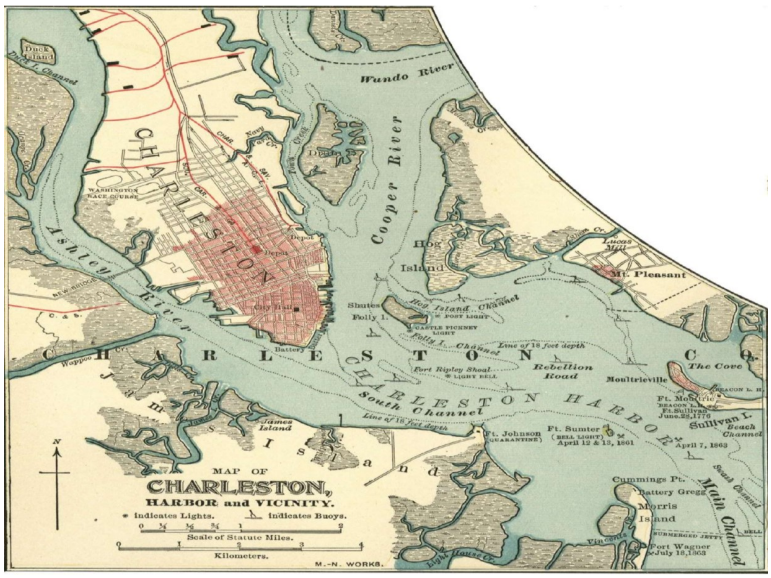
Climate Science and Policy for Nonscientists

One picture is worth a thousand words.

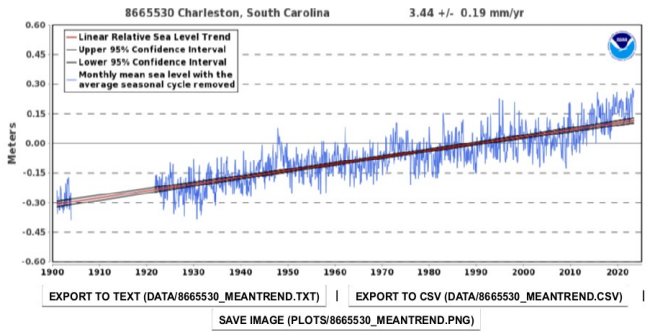
Charleston's Climate Change and Weather Problems - Typical of US Coastal Cities

Charleston has a major climate change problem (rising sea levels) and a major weather problem (hurricanes). The idea for this newsletter came from a book, Charleston - Race, Water, and the Coming Storm (2023) by Susan Crawford, a professor at Harvard Law School, which focuses on how local government has failed disproportionately to protect Black residents of the Charleston area. This newsletter draws on some of the ideas put forward by Prof. Crawford, but presents Charleston's problems in a broader perspective - namely the failure of local, state, and national government to protect all the residents of the Charleston area and of other US coastal cities with similar problems.

Charleston's problems go back to its founding in 1670 when the settlers chose a "very low country, a world of marshes, tidal creeks, and swamps." The Lord Proprietors begged the settlers to move inland to higher and firmer ground, but the settlers wanted to have a port city. Most of the Charleston peninsula where the historic city was founded is less than 10 feet above sea level.



Relative Sea Level Trend
8665530 Charleston, South Carolina

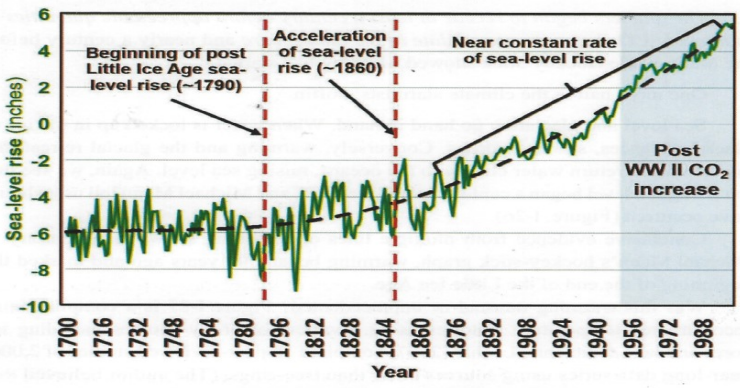


The relative sea level trend is 3.44 millimeters/year with a 95% confidence interval of +/- 0.19 mm/yr based on monthly mean sea level data from 1901 to 2022 which is equivalent to a change of 1.13 feet in 100 years.

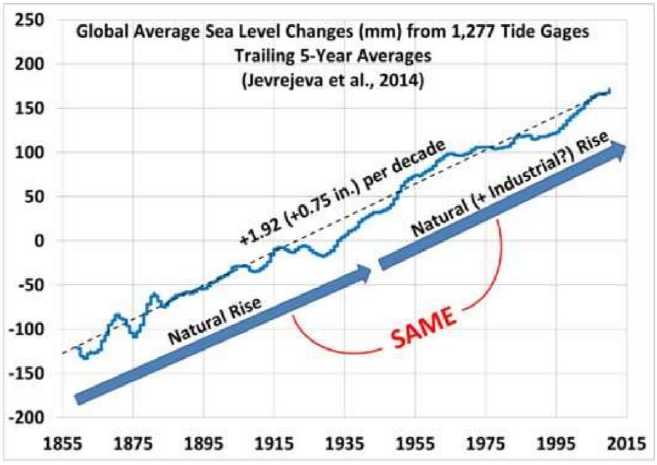
The Charleston tide gauge shows from 1901-2022 a very linear rate of *relative* sea level rise of 3.44 mm per year or 13.6" per century. But Charleston is subsiding (sinking) at about 5" per century, so the *absolute* sea level rise at Charleston is 13.6 - 5 = around 8.6" per century. The sinking is occurring, because Charleston was built on marshy, filled land, which has nothing to do with climate change.

The modern global sea level rise started in the 1790s as the world started to warm following the Little Ice Age, during which, for example, glaciers advanced in the Alps and crushed whole villages.

Figure I-26: Greater than 200 years of sea-level rise

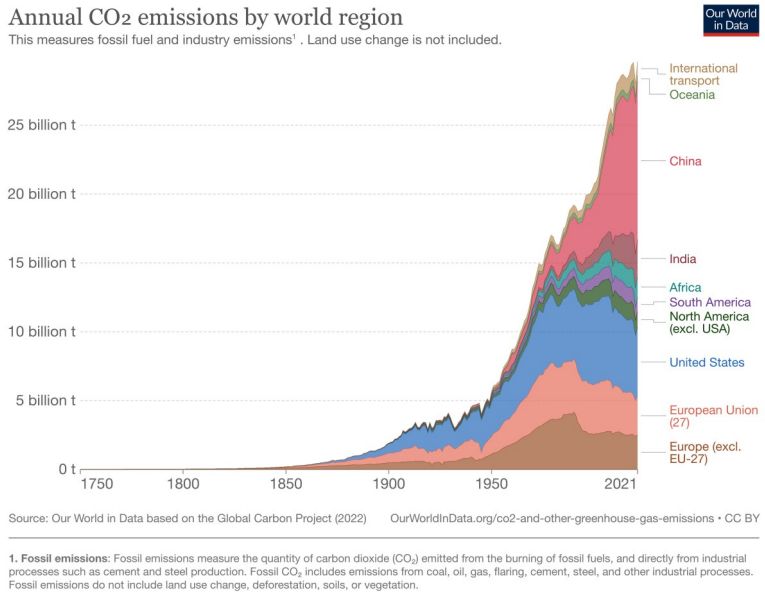


(Source data: Jevrejeva 2008, PSMSL 2008)

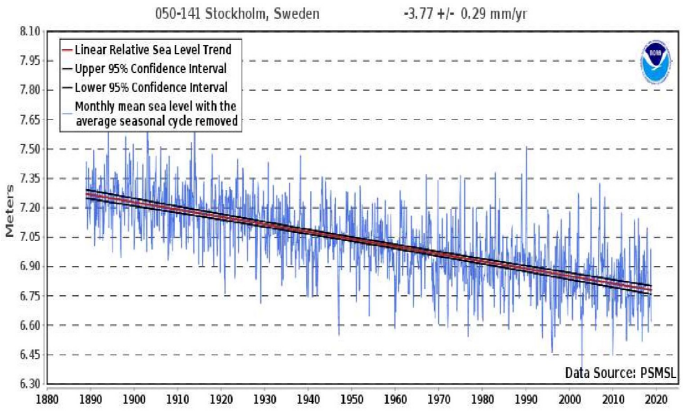


Worldwide tide gauge data shows an average rate of sea level rise of 7.5" per century since 1855, and shows the rate of rise to have been very constant over this period . The graph notes, in particular, no increase in the rate of rise since around 1950 when CO2 emissions started to spike upwards. The IPCC has concluded that sea levels rose from 1901-1971 at 5.1" per century, and from 1971-2006 at 7.5" per century. [AR6 WGI p.5 (2021)].

Human emissions of CO2 did not become significant until around 1950 when such emissions spiked. This new, high rate of rise has continued ever since. But the 7.5" per century rate of sea level rise became embedded in the 1860s long before human activity could be expected to have caused it. The new, high rate of CO2 emissions since 1950 has not caused any increase in the rate of sea level rise, as measured by the tide gauges. The IPCC concluded only that human activity was "very likely" the main driver of sea level rise "since at least 1971," [AR6 WGI p.5 (2021)], when the IPCC believes the rate of rise rose from 5.1" to 7.5" per century. So the IPCC basically concedes that the sea level rise from around 1800 to 1971 was naturally caused.



Stockholm. -3.77 mm/yr = - 14.9 inches/century



The sea level rise problem varies greatly from city to city, because the land level of a particular city may be rising or falling even more that the sea level is rising. For example, Stockholm is rising so fast that the tide gauges show the relative sea level declining at the rate of 14.9" per century.

The subsidence rate varies greatly along the Florida and the US Gulf coast. From New Orleans to Galveston/Houston the land is sinking so rapidly that the *relative* rate of sea level rise might exceed 3 feet per century. Cities along that part of the US coast are seriously exposed to sea level rise. Further North along the Atlantic coast the Virginia Beach area is also sinking particularly rapidly.

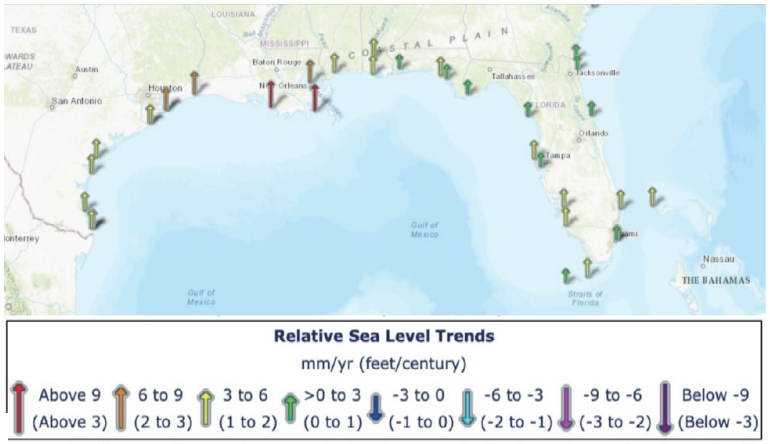
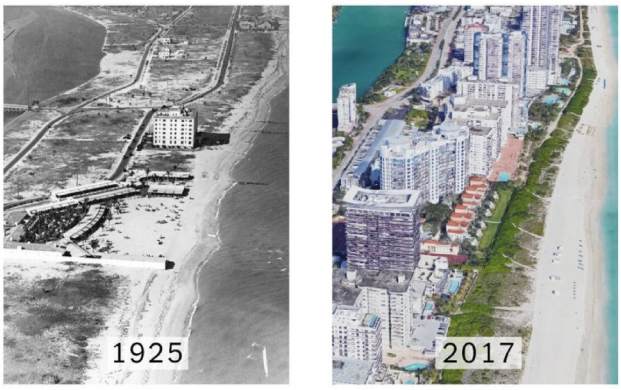


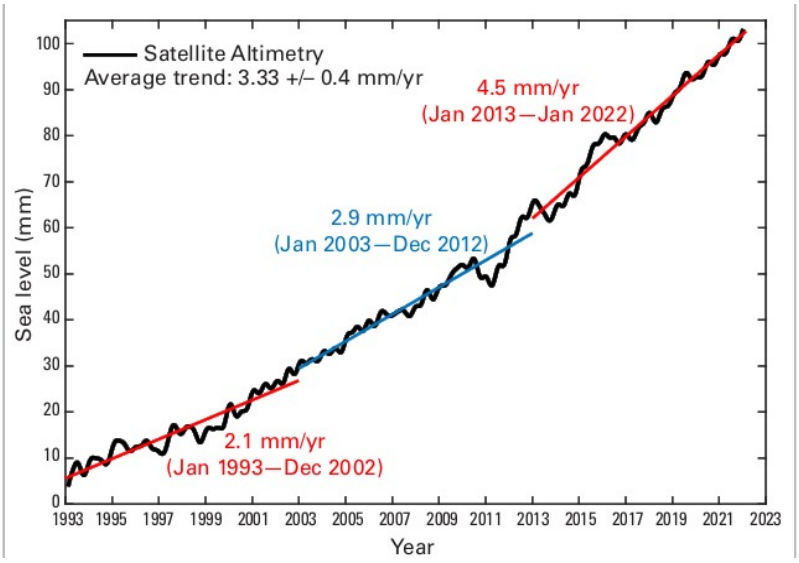
Figure 13. Relative change in sea level at various tide gauge stations along the southeastern US coastline (NOAA). These values essentially provide the net change when considering changes in land elevation as well as sea elevation.

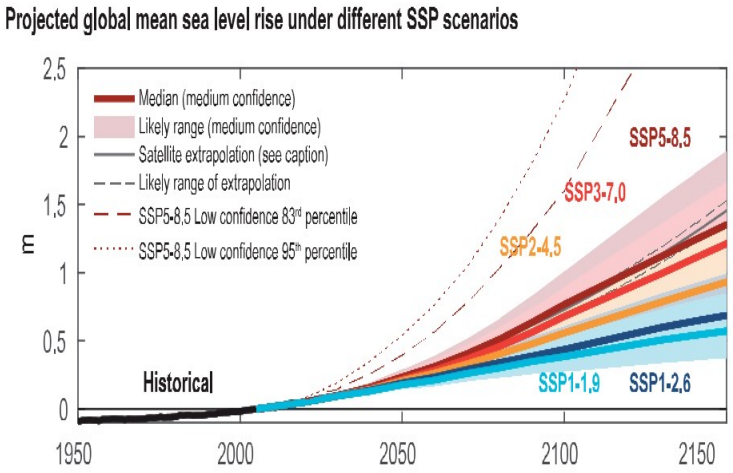
Miami Beach, Then and Now



By contrast, Miami Beach shows minimal sea level rise over a 92 year period, 1925-2017. A recent study of the size of world beaches (Luikendijk 2018) concluded that 24% were shrinking, 48% were stable, and 28% were growing.

Satellite measurements started in 1993 and give significantly different numbers for sea level rise than the tide gauges. The satellite average number since 1993 is 3.33 mm per year or 13.2" per century and over the period 2013-2022 17.8" per century. Scientists still have not been able to explain why the satellite numbers are so much higher than the tide gauge numbers, and why the satellites show the rate of rise increasing when the tide gauges do not. The IPCC in AR6 does not address these issues but nevertheless concludes, based on the satellite data, that sea levels rose from 2006 to 2018 at a rate of 14.6" per century. [AR6 WGI p.5 (2021)].

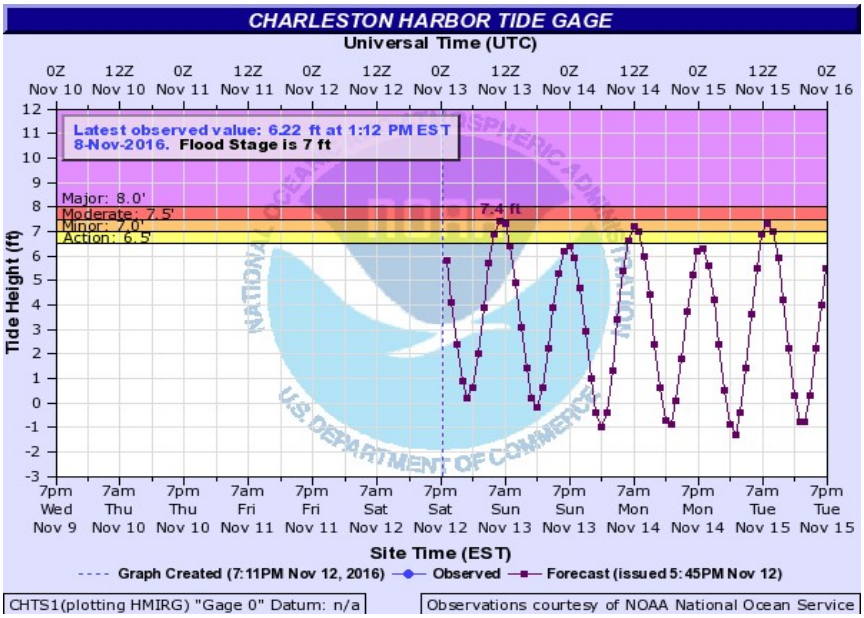




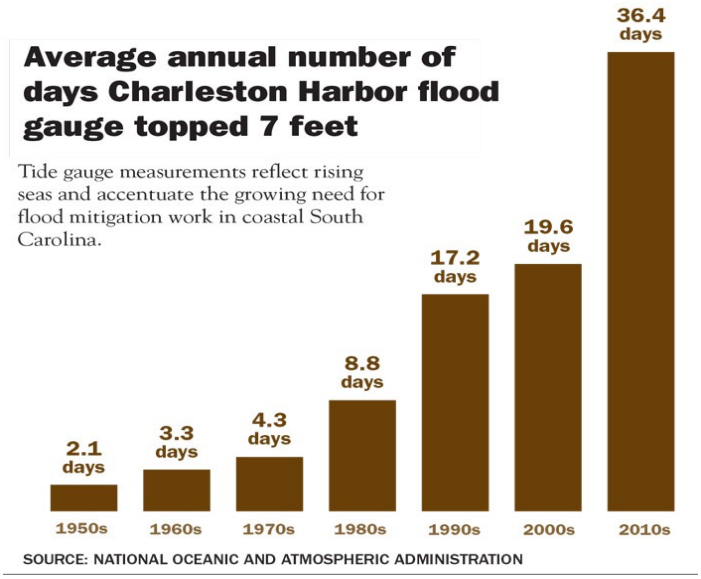
The IPCC projections for future sea levels depend on (1) the particular model used, and (2) the assumptions made by each model as to a variety of variables, most particularly CO2 rise and temperature rise. The graph [AR6 WGI p. 1303 (2021)] shows the results for 5 different sets of assumptions, called "scenarios." The world is probably (but subject to much debate) on a development path that puts it somewhere between SSP1-2.6 and SSP2-4.5.

The IPCC itself does not comment on "the feasibility or likelihood of individual scenarios." [AR6 WGI p. 52 (2021)]. Based on the 2.6 and 4.5 scenarios, the IPCC projects a sea level rise of 17" to 22" from the baseline of 1995-2005 to the year 2100. [AR6 WGI p. 1302 (2021)]. These numbers are much higher than the numbers being actually measured by the tide gauges around the world, but much lower than what is commonly reported in the media.

As mentioned previously, the tide gauge data for Charleston shows a *relative* sea level rise of 13.6" per century, which is the number that Charleston city planners have to worry about. Most of that is naturally occurring - the 5.1" locked in prior to 1971 and the 5" of subsistence = 10.1" of the 13.6". The key point is that Charleston has, in fact, been experiencing increasing rates of tidal flooding. Parts of Charleston that were flooded twice a year in 2000 were flooded 13 times a year in 2019.



At Charleston the swing between high tide and low tide is about 7 feet. The height of high tides varies with a number of factors, such as the phases of the moon and offshore winds. When the High Tide Height hits 7.0 feet on the Charleston tide gauge, the flooding starts, and at 8.0 feet the flooding is "major."



NOAA data shows a significant increase in the number of days per year with high tides reaching or exceeding 7 feet.

Large areas of Charleston County are vulnerable to tidal flooding.

Conclusion as to Sea Level Rise and Tidal Flooding

Charleston's problem with sea level rise and tidal flooding is an example of a slow climate change problem, which makes it easy for politicians to procrastinate and to avoid making difficult decisions. It makes it difficult for the community to agree on a mitigation plan. How high should a sea wall be? Where should it be placed? The higher the wall, the longer the wall, the higher the cost.

The 2022 population of the City of Charleston was only about 154,000. The population of Charleston County was only about 419,000. The county has a county government, and the county contains 3 cities and 3 towns, each with its own government. Limited population means limited local funds are available, and 7 governments makes agreeing on any county-wide flood protection plan difficult.

There have been numerous studies leading to recommendations for action, but no significant action has been taken. For example, a 1984 Master Drainage and Floodplain Management Plan still has not been implemented. Prof. Crawford concludes that Charleston, "like almost all coastal cities, does not have a firm plan to protect its residents from the chronic, debilitating flooding that will arrive in the next few decades." (Op.Cit. p.266)

Most of the sea level rise that Charleston is experiencing (10.1" out of 13.6" per century) is naturally occurring. Science gives us little reason to believe that anything humans can do (such as reducing CO2 emissions) will reduce the rate of sea level rise over the next century below the current rate. There is no choice but to adapt.

CHARLESTON'S WEATHER PROBLEM - HURRICANES

Hurricanes are a fact of life - a feature of natural weather variability. In 1900 a hurricane destroyed Galveston and killed between 8,000 and 12,000 people. The chaos was such that it has been impossible to estimate the numbers killed with any greater accuracy. The deadliest hurricane in history was the hurricane of 1780 that killed between 22,000 and 27,000 people in the Caribbean.

In 1901 the Texas Legislature funded a 17 foot high sea wall for Galveston.

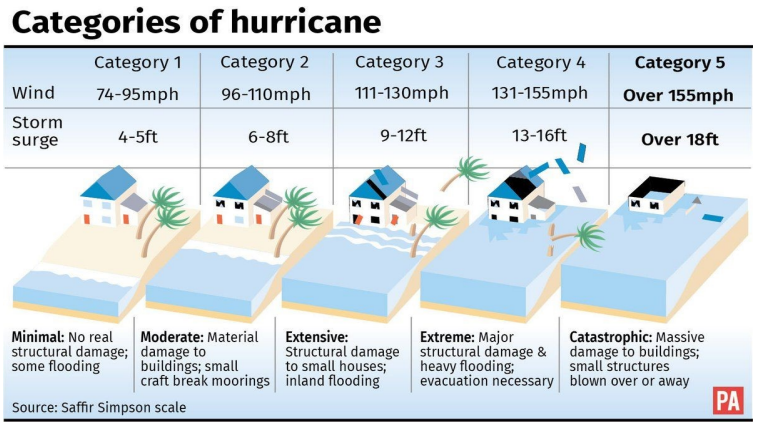
The Great Miami Hurricane of 1926 devastated the greater Miami area. It was a Cat.4 storm with a highest wind speed of 150 mph. Estimated killed were 352-539+. If that hurricane struck today, it would probably establish a new world record for the greatest monetary damage caused by a single hurricane.

But today Miami still does not have a sea wall. Much of Miami is built right up against the shore, and its average elevation is only 6 feet (comparable to Charleston). Miami Beach remains defenseless. (See previous picture). The US Army Corps of Engineers in 2021 proposed building a 20 foot high sea wall to protect 6 miles of downtown and the financial district, which would still have left most of the city unprotected. The proposal has not been approved.

Much of Miami is built right up to the water's edge. On average, it's 6 feet above sea level.

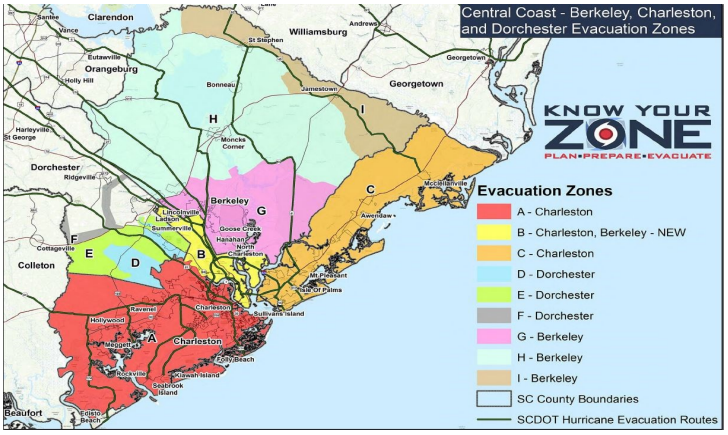
Sea walls must to be properly designed, built, and maintained. After Betsy flooded New Orleans in 1965 Congress authorized the Corps of Engineers to begin a major overhaul of the region's levees, but the project was still incomplete by the time Katrina hit in 2005. Katrina was a Cat.5 storm at maximum strength but was Cat.3 when it hit New Orleans. The levee system, which was supposed to protect against Cat.3 storms, failed, which was a major cause of the resulting flooding and loss of life (more than 1,500 deaths). Since Katrina, federal, state, and local governments have spent over $20 billion to try to make New Orleans safe. About half of New Orleans is below sea level.

Today Charleston is virtually defenseless against hurricanes. A Cat.3 hurricane can be expected to produce a 9-12 foot storm surge, which would probably inundate the entire Charleston peninsula and other large areas of Charleston County. In August 2023 what once was Hurricane Idalia hit Charleston. By the time it reached Charleston (approaching overland from Georgia) it was no longer a hurricane but just a "tropical storm," meaning wind speeds 39-73 mph. Nevertheless the flooding was knee-high on some of Charleston's streets.



In 1989 Hurricane Hugo hit Charleston County as a Cat.4 storm. The storm surge was 20 feet. 56,000 people were left homeless. The National Weather Service wind gauge broke at 137 mph. 3,000 tornadoes were spawned. 29 of South Carolina's 46 counties were declared disaster areas. Since then building codes have been tightened up to require stronger construction, but not much else has changed. People seem to feel, "Hugo was the storm of the century - we won't see another like it for 100 years."

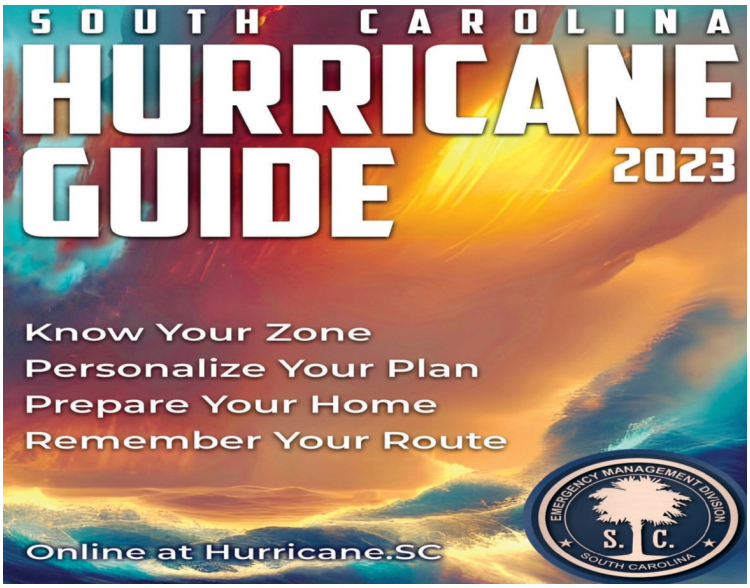
Charleston now does have an evacuation plan.



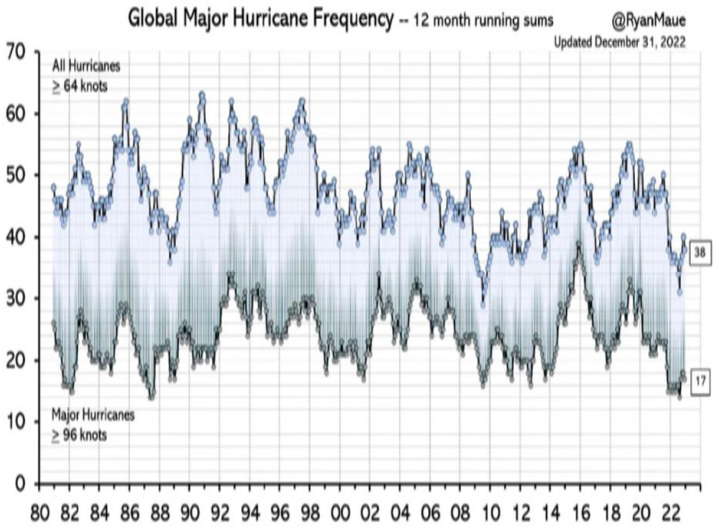
Charleston County
Hurricane Preparedness Guide

Are YOU Ready?

Charleston County has a hurricane preparedness guide



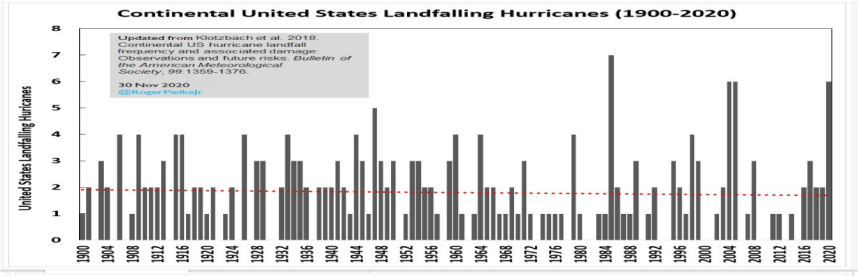
And South Carolina has an extensive Hurricane Guide.

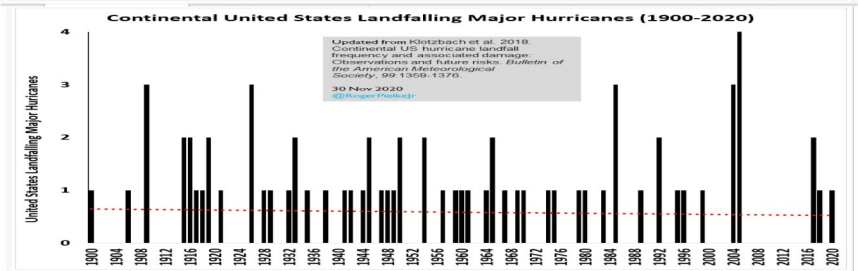


Running 12 month sums of global hurricane and major hurricane counts.

On Average since 1980 there have been roughly 40 hurricanes worldwide per year about half of which have been major hurricanes (Cat 3+). The trend has been slightly down, and recent years have been slightly below average. Hurricanes are part of natural weather variability. The IPCC could not find any increase in the frequency of any category hurricane. [AR6 WGI p.9 (2021)]. In view of contrary statements that often appear in the media, it is worth repeating - there is no measured increase in the frequency of Cat.3, Cat.4, or Cat.5 storms. There has been no climate change with respect to hurricane frequency or intensity.

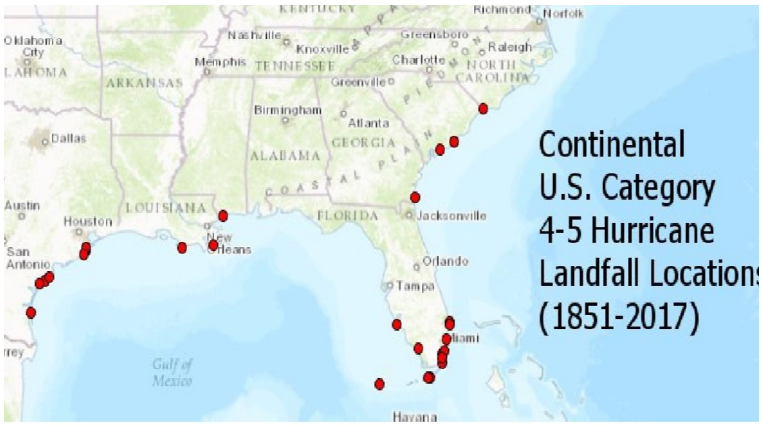
On average about 2 hurricanes hit the US each year, and about one major hurricane every 2 years. The trend in both is slightly down. In many years no major hurricane hits the US, but there is great variability from year to year The IPCC could not find any trend in the frequency of US landfall events. [AR6 WRI p.1585 (2021)].

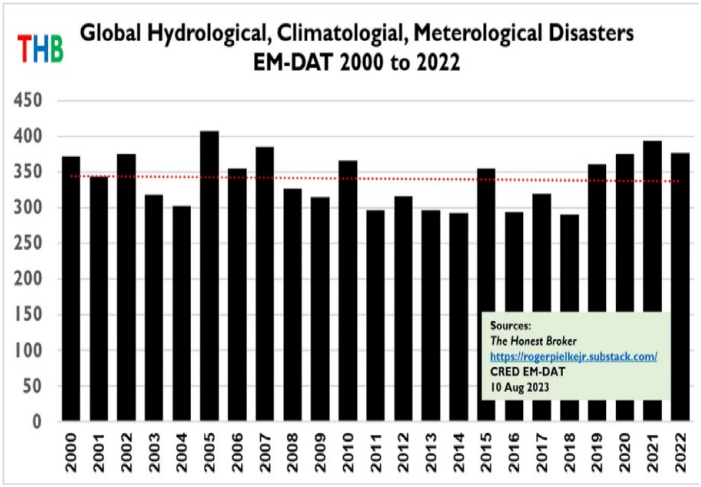




There have been only 4 storms that hit the US at Cat.5 strength. All have hit Florida or along the Gulf coast. The average time between such storms has been 28 years.

There have been about 30 storms that have hit the US at Cat.4+ strength since 1851. Most have hit either Florida (particularly the South-East coast) or Texas-Louisiana. On average there has been about one such storm every 5-6 years.

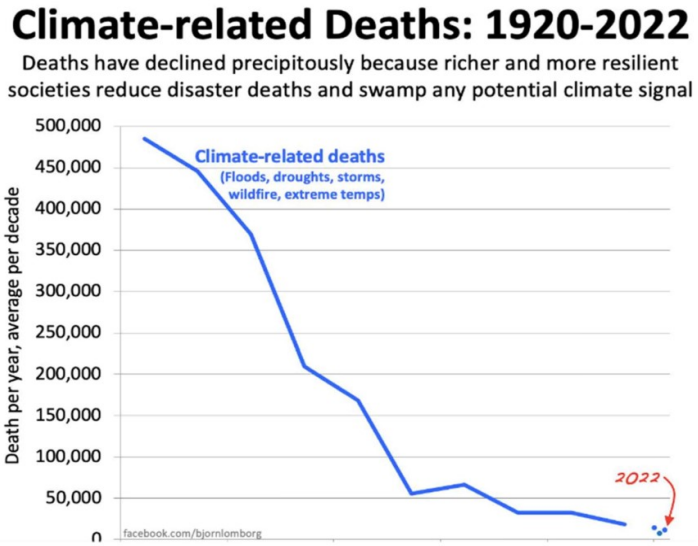




Source: EM-DAT downloaded 10 Aug 2023

Good news is that the number of climate disasters per year since 2000 has shown no increase.

Very good news is that over the last century climate-related deaths are down dramatically. Scientists can spot hurricanes far offshore and have made great progress at predicting the paths of hurricanes. Warnings are issued to the areas that may be hit, preparations are made, and evacuations are conducted when advisable. Bangladesh particularly has benefitted: 1970 Cyclone Bhola (wind speeds 185 km/h) killed an estimated half million people. 1991 an unnamed cyclone (wind speeds 235 km/h) killed 138,000. 2007 Cyclone Sidr (wind speeds 215 km/h) killed 3,400. 2020 Cyclone Amphan (wind speeds 240 km/h) killed 26.



Conclusion as to Hurricanes

Local, state, and federal governments have all failed to provide Charleston with a defense against hurricane storm surge, which could inundate most of the urban area. Cat.4 and Cat.5 storms striking the Carolinas are so rare that it is questionable whether the expense of defense is justifiable. Unfortunately to protect the Charleston area against a Cat.3 storm would still be very expensive. Would the benefit be worth the cost? What are the odds of a Cat.3 storm striking Charleston within the next 50 years, and how much damages would be avoided if the defenses held? But, if present trends continue, roughly 3 Cat.4+ storms will hit somewhere along the US coast (most likely Florida, Texas, or Lousiana) within the next 20 years. Our political systems have difficulty responding to this type of problem (low likelihood but very high potential damages).

Indonesia has decided to move its capitol from Jakarta, a coastal city, which has been described as the "world's most rapidly sinking city." At some point in time US cities may have to resort to "coastal retreat" or "strategic withdrawal," terms used by Prof. Crawford. Families, businesses, and institutions individually will start to decide to move to safer locations. Prof. Crawford mentions as an example the Roper Hospital, one of Charleston's largest employers, which in 2021 announced a new strategic plan that included moving off the peninsula by 2030.

Insurers are declining to provide coverage in California, Louisiana, and Florida, the three states considered at greatest risk of natural disaster. One study has found that 17% of homeowners in Louisiana had had their policies cancelled in 2022. Can small cities like Charleston and small towns afford to rebuild all their roads and bridges repeatedly damaged by flooding? One researcher has commented, "The insurance pullouts we've seen in the last couple of years are the canary in the coal mine." After insurers withdraw, banks will start declining to make mortgage loans on uninsured properties, which will lead eventually to a collapse of real estate values.

Hurricanes will always be with us. They are a weather problem, not a climate change problem. Science gives us little reason to believe that anything humans can do over the next century (such as reducing CO2 emissions) will reduce hurricane frequency or intensity below current levels. There is no choice but to adapt.

Works Cited

Intergovernmental Panel on Climate Change, Assessment Report 6, Working Group 1, The Physical Science Basis (2021) (AR6 WGI)

Charleston - Race, Water, and the Coming Storm (2023) by Susan Crawford,