CLIMATE CENTRAL

Climate change increased wind speeds for every 2024 Atlantic hurricane: Analysis

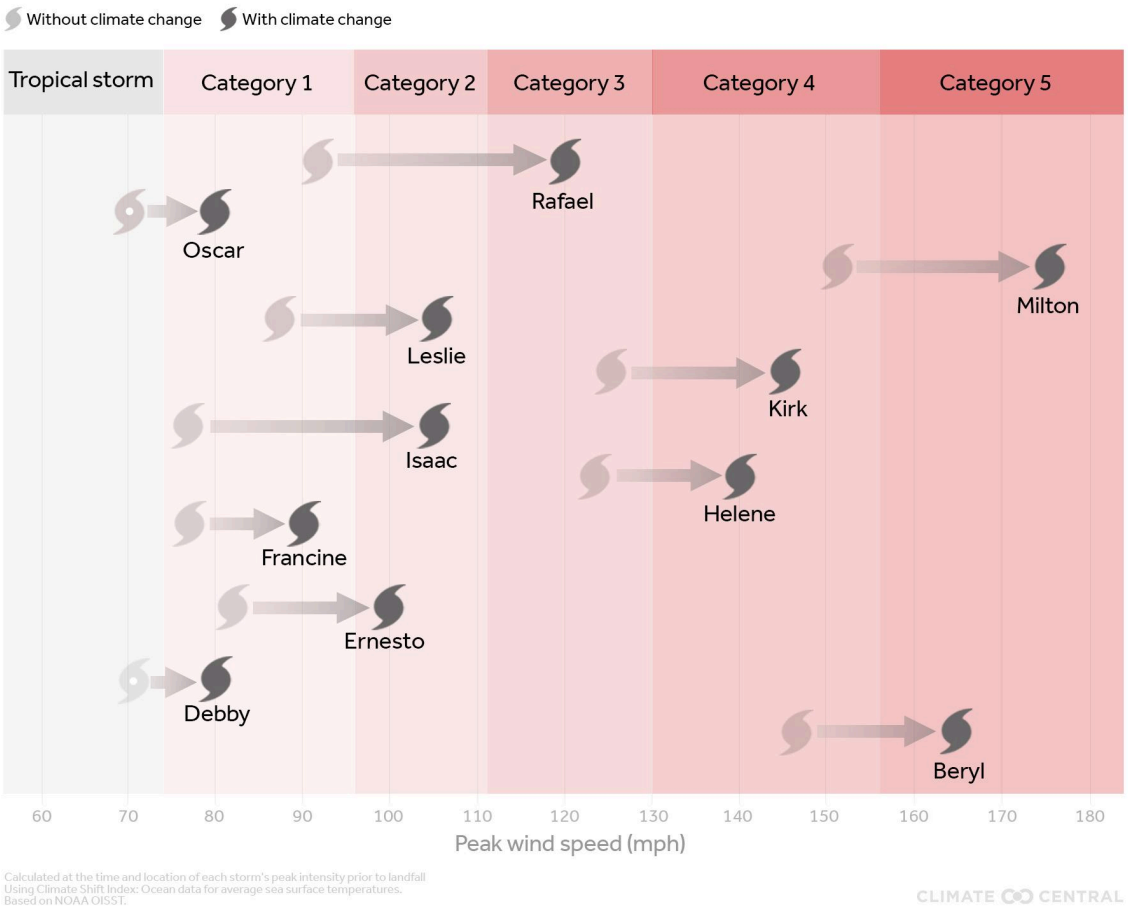
November 20, 2024

Climate change increased maximum wind speeds for every Atlantic hurricane in 2024, according to a Climate Central analysis based on new, peer-reviewed research. Human-caused global warming elevated ocean temperatures and boosted all eleven storms' intensities, increasing their highest sustained wind speeds by 9 to 28 miles per hour. This increase moved seven of the hurricanes into a higher Saffir-Simpson Hurricane Scale category and strengthened Hurricanes Debby and Oscar from tropical storms into hurricanes.

This analysis used the methodology from a new study published on November 20, 2024, in Environmental Research: Climate, which introduced a rapid attribution framework to assess the impact of human-caused ocean warming on hurricane intensities. The study, *Human-caused ocean warming has intensified recent hurricanes* (Gilford et al., 2024), applied this framework to Atlantic hurricanes from 2019-2023, and these findings cover the 2024 Atlantic hurricane season.

Key findings

- All eleven hurricanes in 2024 (as of November 10) intensified by 9-28 mph during the record-breaking ocean warmth of the 2024 hurricane season, strengthening over waters made as much as 2.5°F warmer because of climate change.
- Climate change made elevated sea surface temperatures (SST) in the tracks of 2024 hurricanes up to 800 times more likely.
- Human-warmed ocean temperatures made major hurricanes Helene and Milton even stronger, adding 16 mph and 24 mph, respectively.



Results: No Atlantic hurricane in 2024 escaped the record-breaking ocean heat

The 2024 hurricane season was one of the hottest ever in the North Atlantic basin. In many regions across the basin, sea surface temperatures broke their local seasonal records or were second only to the similarly extreme 2023 season. According to the *Climate Shift Index: Ocean* — a system grounded in peer-reviewed methodology that quantifies the influence of climate change on sea surface temperatures — daily temperatures across the analyzed region were made, on average, at least 44 times more likely to occur in today's climate than in a world without climate change. Five out of the eleven hurricanes in 2024 crossed the Gulf of Mexico where human-caused ocean warming made temperatures about 2°F hotter than they would have been in a world without it.

This profound Atlantic warming translated to an increase in each storm's potential upper bound on intensity, or maximum sustained wind speed before landfall. This warming also increased the likelihood that each storm would undergo rapid intensification during its lifetime. As a result, the wind speed of every single 2024 Atlantic hurricane (Table 1) was higher because of human-caused ocean warming. During the 2024 season, the average attributable change in intensity due to human-caused ocean warming ranged between 9 and 28 mph. Overall, storms increased by about one category. Hurricanes Isaac and Rafael tied for the largest attributable increase in wind speed at 28 mph.

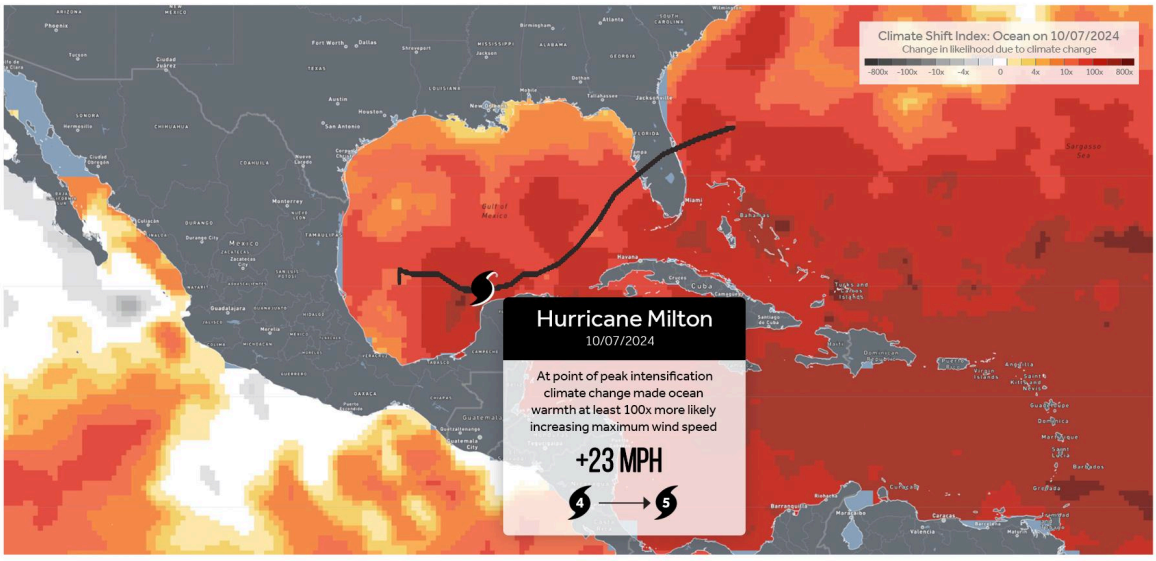
Climate change collectively increased the intensities of the four billion-dollar disaster storms (projected losses over $1 billion USD) — Hurricanes Beryl, Debby, Helene, and Milton — by an average of 17 mph. Climate change-warmed sea surface temperatures intensified Hurricane Helene by 16 mph and Hurricane Milton by 23 mph. These estimates compare favorably to earlier estimates from World Weather Attribution, increasing confidence in both approaches. WWA scientists used the independent IRIS attribution model, and found similar at-landfall changes of 14 mph and 11 mph, respectively.

Hurricane	Maximum intensity	Increase in maximum intensity
Beryl	165 mph	18 mph
Debby	80 mph	9 mph
Ernesto	100 mph	18 mph
Francine	90 mph	13 mph
Helene	140 mph	16 mph
Isaac	105 mph	28 mph
Kirk	145 mph	20 mph
Leslie	105 mph	18 mph
Milton	175 mph	23 mph
Oscar	85 mph	9 mph
Rafael	120 mph	28 mph

Table 1. Observed hurricane maximum wind speeds (mph) before landfall and the increases in wind speed due to human-caused ocean warming for each storm during the 2024 Atlantic hurricane season (through November 11, 2024).

Hurricane Milton

And the increases in wind speed due to human-caused ocean warming



Calculated at the time and location of Milton's peak intensity prior to landfall
Using Climate Shift Index: Ocean data for average sea surface temperatures.
Based on NOAA OISST.

CLIMATE CENTRAL

Summary of new peer-reviewed study: Hotter oceans, higher winds

The above analysis is based on the methodology of a new peer-reviewed study, published in Environmental Research: Climate on November 20, 2024: “Human-caused ocean warming has intensified recent hurricanes.” Below is a brief summary of the study's key findings.

Much of the North Atlantic basin has warmed faster than other regions. Since 1900, the region has warmed 2°F, compared with the 1.6°F of global ocean warming observed across ice-free latitudes. Record-breaking Atlantic water temperatures over recent hurricane seasons (June-November, 2019-2023) have proved a powerful fuel source for storms to intensify, increasing their damages and overall impacts on human society.

The influence of climate change on hurricane intensities from 2019-2023 was ubiquitous and robust:

- On average, hurricane wind speeds at their peak before landfall were approximately 18 mph faster because of climate change.
- Hurricanes over the last five years were, on average, one extra Saffir-Simpson category more intense than they would have been in a world without ocean warming caused by climate change.

- Five out of every six storms (84%) were made significantly more intense because of human-caused ocean warming.
- Recent Atlantic storms that would have been a category weaker in a world without human-caused ocean warming include Hurricanes Sally (2020), Ian (2022), and Franklin (2023).

This peer-reviewed framework serves as a new paradigm for hurricane attribution. As future tropical cyclones develop and threaten coastal communities around the world, this framework allows us to rapidly estimate and communicate the extent to which human beings have influenced storm intensities.

METHODS

Using Climate Central's *Climate Shift Index: Ocean* (Ocean CSI) as a foundation, we applied a novel peer-reviewed approach (Gilford et al., 2024) to calculate the attributable influence that oceans warmed by human-caused carbon pollution have had on the hurricane intensities observed in the Atlantic Ocean basin since 2019.

The Ocean CSI tool was first used to rapidly compute the influence of human-caused climate change on sea surface temperatures. The methodology underpinning this tool is based on peer-reviewed research (Giguere et al., 2024).

Using the newly published hurricane attribution framework (Gilford et al., 2024), we produced estimates of the degree to which recent hurricanes have intensified in response to attributable ocean warming. The method evaluates the extent to which the theoretical maximum wind speed of the environment (called "potential intensity"; e.g. Gilford 2021) has increased in response to human-caused ocean warming. Next, using the known relationship between potential intensity and observed intensity (Sobel et al., 2016), the system computes a counterfactual hurricane intensity consistent with the calculated attributable shift in potential intensity.

The wind speed difference between the estimated counterfactual and known observed lifetime maximum intensities is the change in hurricane intensity attributable to human-caused ocean warming (reported in miles per hour).

Hurricane tracks are drawn from the NHC GIS Archive - Tropical Cyclone Best Track dataset (*accessed 11/10/24*). We consider all storms which reached at least Category 1 strength (≥74 mph). ERA5 data are drawn from the Copernicus Climate Data Store (*accessed 11/10/24*). Potential intensities during the 2024 Hurricane Season are evaluated with a seven-day rolling average, in order to smooth out spurious influences from real-time environmental-hurricane interactions.

REPORT CONTRIBUTIONS

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