

## **CSU researchers slightly over predict extremely active 2024 Atlantic hurricane season**

*Note to Reporters:* The full verification report and a chart showing the predicted vs. observed storms are available with this news release at <http://tropical.colostate.edu/>. This report includes an extensive discussion of the climate features that caused the 2024 hurricane season to end up extremely active despite a marked mid-season lull.

**FORT COLLINS, COLORADO** – The 2024 Atlantic hurricane season ended up as extremely active, although slightly less than what was forecast by the Tropical Weather and Climate Research Team at Colorado State University with its outlooks issued in April, June, July and August. Colorado State University's initial seasonal forecast in April and first update in June were the most accurate of the 2024 predictions. Both of these forecasts exactly predicted the observed number of hurricanes (11) and major hurricanes (5) that occurred. Eighteen named storms formed in 2024, which was somewhat less than the 23 named storms predicted in April, June and August and well below the 25 named storms predicted in July. The average Atlantic hurricane season has 14 named storms, 7 hurricanes and 3 major hurricanes. Five hurricanes made landfall in the continental United States in 2024, with Helene and Milton making landfall as major hurricanes. The continental US hurricane landfalls of 2024 (Beryl, Debby, Francine, Helene and Milton) combined to cause ~250 fatalities with preliminary damage estimates of ~\$100 billion USD.

“The 2024 Atlantic hurricane season ended up extremely active. Our seasonal forecasts anticipated an extremely active season, although our forecasts slightly over predicted activity that occurred. The forecasts for hurricanes and major hurricanes were quite accurate, while we somewhat over predicted the amount of named storm activity as well as Accumulated Cyclone Energy that occurred,” said Phil Klotzbach, lead author of the forecast. Accumulated Cyclone Energy is an integrated metric accounting for intensity and duration of storms. Observed seasonal Accumulated Cyclone Energy (ACE) was approximately 130% of the 1991–2020 average, while CSU predicted ACE to be approximately 170% of the 1991–2020 average with their April and June outlooks and 185% of the 1991–2020 average with their July and August outlooks.

Colorado State University also continued to forecast ACE west of 60°W, as ACE in the western part of the basin is likely more impactful to populated areas. They correctly anticipated a higher percentage of basinwide ACE occurring west of 60°W this year, due in part to cool neutral ENSO conditions favoring tropical cyclone activity in the western part of the Atlantic. This was certainly the case in 2024, when in addition to devastating hurricanes impacting the continental US, Beryl caused significant impacts in the eastern Caribbean, Oscar and Rafael caused significant damage in Cuba, and Sara caused catastrophic flooding in Honduras.

The report summarizes all tropical cyclone activity in the Atlantic basin during the 2024 hurricane season and compares the team's seasonal and two-week forecasts to what occurred.

The extremely active Atlantic hurricane season was likely driven in part by at or near record warm sea surface temperatures in the tropical Atlantic and Caribbean. The tropical Pacific was characterized by cool neutral ENSO conditions, which favors more conducive Atlantic hurricane conditions due to reduced levels of vertical wind shear (the change in wind direction and speed with height). The combination of extremely warm Atlantic sea surface temperatures and cool neutral ENSO contributed to record low levels of tropical Atlantic and Caribbean vertical wind shear during August–October. Despite these extremely favorable conditions, the Atlantic underwent a remarkable mid-season lull, with the longest mid-season named storm formation drought since 1968. This lull was likely driven by a combination of factors including a northward shift in the Atlantic easterly wave track, considerable dry air advection into the tropical Atlantic, anomalously warm upper levels suppressing deep convection, and a brief increase in Atlantic vertical wind shear during mid-September associated with unfavorable subseasonal conditions driven by the Madden-Julian oscillation. These hurricane-unfavorable conditions switched to extremely hurricane-favorable conditions in late September. The late season was hyperactive, with tropical cyclone activity in the Atlantic from 24 September – onwards being at or near record high levels for several tropical cyclone parameters.

The team bases its annual forecasts on 70 years of historical data and includes factors such as Atlantic sea surface temperatures and sea level pressures, vertical wind shear, El Niño (an anomalous warming of waters in the central and eastern tropical Pacific) and other factors. While these forecast factors generally work well and explain approximately 50–60 percent of the year-to-year hurricane variability in these 70 years of historical data, there remains 40–50 percent of this variability which is not explained.

Hurricane statistics for 2024 contained in the report include:

- 11 hurricanes formed in the Atlantic. 2024 tied with 1995 for 5<sup>th</sup> place for hurricanes produced in the satellite era (1966–onwards).
- 5 hurricanes made landfall in the continental US (Beryl, Debby, Francine, Helene and Milton). 2024 tied with 1893, 2004 and 2005 for the 2<sup>nd</sup>-most continental US hurricane landfalls. 1886, 1985 and 2020 had 6 continental US hurricane landfalls – the most on record.
- No named storms formed in the Atlantic between 13 August – 8 September. The last time that this occurred was in 1968.
- 11 named storms formed in the Atlantic since 24 September. 2024 is tied with 2005 for the record for most named storm formations from 24 September – onwards.
- 7 hurricanes formed in the Atlantic since 25 September – the most on record from 25 September – onwards.

- Kirk, Leslie and Milton were hurricanes simultaneously – the first time on record that the Atlantic had 3 hurricanes simultaneously from October – onwards.
- Hurricane Beryl became a Category 5 hurricane on 2 July – the earliest forming Atlantic Category 5 hurricane on record. The prior record was Emily (2005) on 17 July.
- Hurricane Helene (Category 4; 120 kt) was the strongest hurricane to make landfall in the Big Bend on record. The prior record was the Cedar Keys Hurricane (1896; Category 3; 110 kt).
- Hurricane Milton had a lifetime minimum central pressure of 897 hPa – the lowest for an Atlantic hurricane since Wilma (2005).
- Hurricane Rafael was only the 2<sup>nd</sup> major hurricane on record in the Gulf of Mexico in November. The other Gulf major hurricane in November was Kate (1985).

The Tropical Weather and Climate Research Team has attributed the general upturn in major hurricane activity since 1995 as well as the earlier increase in major hurricane activity from the late 1940s through the mid-1960s to be primarily due to natural multi-decadal variability in the strength of the Atlantic Multidecadal Oscillation (AMO). A concomitant increase in several favorable hurricane-enhancing parameters occur in the tropical Atlantic during the positive phase of this oscillation - while these same parameters tend to suppress hurricanes during the negative phase of this oscillation. An additional driver of the increase in Atlantic hurricane activity in recent years may be a reduction in sulfate aerosols across the tropical Atlantic due to the Clean Air Act, allowing for additional warming of the tropical Atlantic. Warming sea surface temperatures and increases in atmospheric water vapor may also be fueling the observed increase in the percentage of hurricanes reaching Category 4-5 intensity and high-end rapid intensification events. However, this is a global trend with wider scope than year-to-year predictions of tropical cyclone activity in one basin.

CSU's seasonal hurricane forecasts were developed by the late Dr. William Gray and have been issued every year since 1984. The first forecast for the 2025 Atlantic hurricane season will be issued on Thursday, 3 April.

## ATLANTIC BASIN SEASONAL HURRICANE FORECASTS FOR 2024

Forecast Parameter and 1991–2020 Average (in parentheses)	Issue Date 4 April 2024	Issue Date 11 June 2024	Issue Date 9 July 2024	Issue Date 6 August 2024	<b>Observed 2024 Activity Thru 11/26</b>	% of 1991– 2020 Average
Named Storms (NS) (14.4)	23	23	25	23	<b>18</b>	125%
Named Storm Days (NSD) (69.4)	115	115	120	120	<b>77.25</b>	111%
Hurricanes (H) (7.2)	11	11	12	12	<b>11</b>	153%
Hurricane Days (HD) (27.0)	45	45	50	50	<b>37.50</b>	139%
Major Hurricanes (MH) (3.2)	5	5	6	6	<b>5</b>	156%
Major Hurricane Days (MHD) (7.4)	13	13	16	16	<b>11.50</b>	155%
Accumulated Cyclone Energy (ACE) (123)	210	210	230	230	<b>162</b>	132%
ACE West of 60°W (73)	125	125	140	140	<b>100</b>	137%
Net Tropical Cyclone Activity (NTC) (135%)	220	220	240	240	<b>189</b>	140%