

# Tropical Cyclone

This indicator examines the intensity of hurricanes and other tropical storms in the Atlantic Ocean, Caribbean, and Gulf of Mexico.

## Background

Hurricanes, tropical storms, and other intense rotating storms fall into a general category called cyclones. There are two main types of cyclones: tropical and extratropical. Tropical cyclones get their energy from warm tropical oceans, while extratropical cyclones form outside the tropics, getting their energy from the jet stream and from temperature differences between the north and the south, often involving cold fronts and warm fronts.

This indicator focuses on tropical cyclones in the Atlantic Ocean, Caribbean, and Gulf of Mexico. Tropical cyclones are most common during the “hurricane season,” which runs from June through November. The effects of tropical cyclones are numerous and well known. At sea, storms disrupt and endanger shipping traffic. When cyclones encounter land, their intense rains and high winds can cause property damage, loss of life, soil erosion, and flooding. The associated storm surge—the large volume of ocean water pushed ashore by the cyclone’s strong winds—can also cause severe flooding and destruction.

Climate change is expected to affect tropical cyclone intensity by increasing sea surface temperatures, a key factor that influences cyclone formation and behavior. According to the U.S. Global Change Research Program, it is very likely that increased levels of greenhouse gases have contributed to an increase in sea surface temperatures in areas where hurricanes form, suggesting a human contribution to hurricane activity over the last 50 years.<sup>22</sup> The U.S. Global Change Research Program and the Intergovernmental Panel on Climate Change project that tropical cyclones will become more intense, with higher wind speeds and heavier rains.<sup>23</sup> However, observations of past cyclone activity and projections of future activity have uncertainties because of changes in monitoring technology, longer-term regional climate patterns, and the limitations of climate models.

## About the Indicator

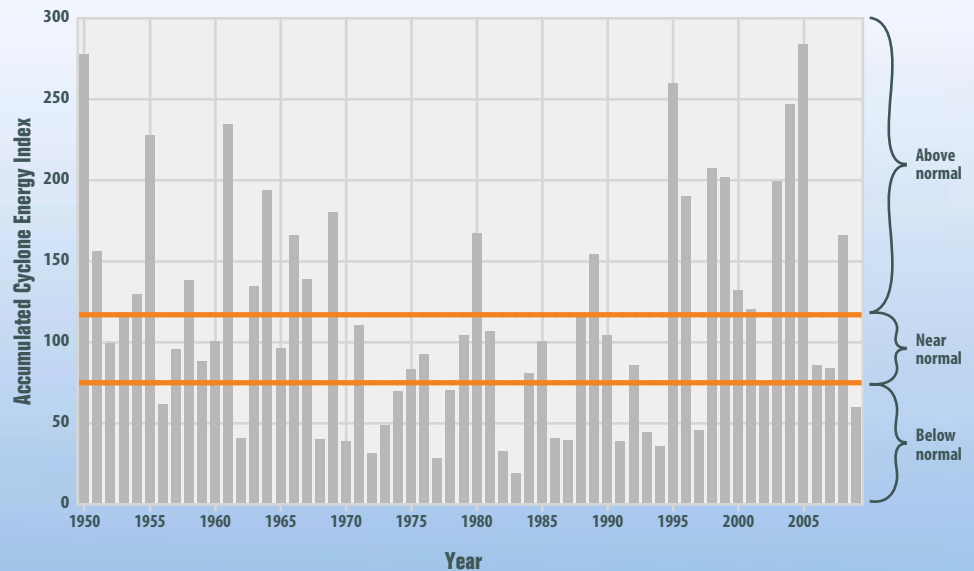
This indicator uses two related indices: the Accumulated Cyclone Energy (ACE) Index and the Power Dissipation Index (PDI).

The National Oceanic and Atmospheric Administration uses the ACE Index to measure the strength of individual tropical storms as

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**Figure 1. North Atlantic Cyclone Intensity According to the Accumulated Cyclone Energy Index, 1950–2009**

This figure shows total annual Accumulated Cyclone Energy (ACE) Index values from 1950 through 2009. The National Oceanic and Atmospheric Administration has defined “near normal,” “above normal,” and “below normal” ranges based on the distribution of ACE Index values over the 50 years from 1951 to 2000.



Data source: NOAA, 2010<sup>24</sup>



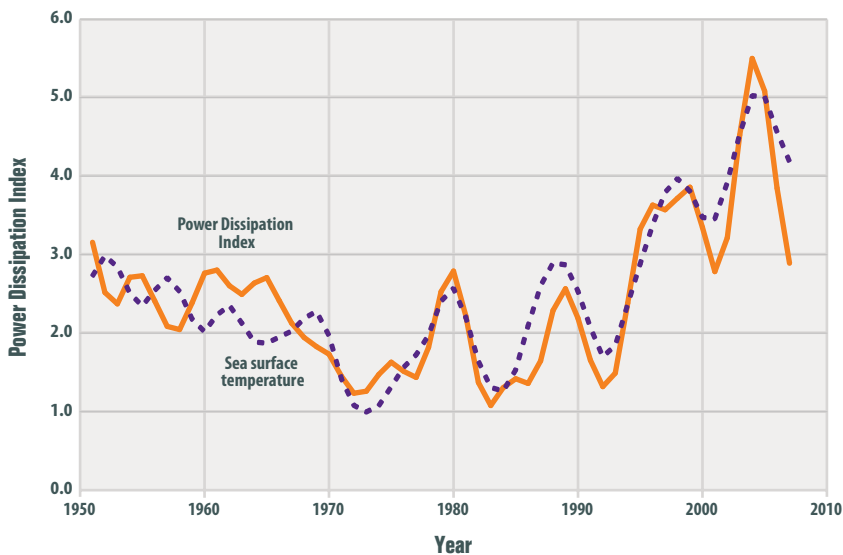
# Intensity

## Key Points

- When examining the entire ACE Index data series from 1950 to 2009, no clear trends in cyclone intensity are apparent (see Figure 1). However, intensity has risen noticeably over the past 20 years, and six of the 10 most active years have occurred since the mid-1990s. Comparable levels of activity were also seen during the previous high-activity era which spanned the 1950s and 1960s.
- The PDI (see Figure 2) shows a similar trend: fluctuating cyclone intensity for most of the mid- to late 20<sup>th</sup> century, followed by a noticeable increase since 1995. These trends are closely related to variations in sea surface temperature in the tropical Atlantic (see Figure 2), leading the U.S. Global Change Research Program to conclude that hurricane activity has “increased substantially since the 1950s and ’60s in association with warmer Atlantic sea surface temperatures.”<sup>25</sup>

## Figure 2. North Atlantic Cyclone Intensity According to the Power Dissipation Index, 1949–2009

This figure presents annual values of the Power Dissipation Index (PDI). North Atlantic sea surface temperature trends are provided for reference. Note that sea surface temperature uses different units, but the numbers have been adjusted here to show how the trends are similar. The lines have been smoothed using a five-year weighted average.



Data source: Emanuel, 2010<sup>26</sup>

well as the total cyclone activity over the course of a hurricane season. An individual storm's ACE Index value is a number based on the storm's maximum wind speed measured at six-hour intervals over the entire time when the cyclone is classified as at least a tropical storm (that is, a storm with a wind speed of at least 39 miles per hour). Therefore, the ACE Index value accounts for both cyclone strength and duration.

The National Oceanic and Atmospheric Administration calculates the ACE Index value for an entire hurricane season by adding the ACE Index values for all named storms in a season, including subtropical storms, tropical storms, and hurricanes. For this indicator, the ACE Index has been converted to a numerical scale where 100 equals the median value (the midpoint) over a base period from 1951 to 2000. The National Oceanic and Atmospheric Administration has set specific thresholds (see Figure 1) to define whether the ACE Index for a given year is close to normal, significantly above normal, or significantly below.

For additional perspective, this indicator also shows trends in the PDI. Like the ACE Index, the PDI is based on measurements of wind speed, but it uses a different calculation method that places more emphasis on storm intensity. This indicator shows the annual PDI value, which represents the sum of PDI values for all named storms during the year.

## Indicator Limitations

Over time, data collection methods have changed as technology has improved. For example, wind speed collection methods have evolved substantially over the past 60 years. How these changes in data gathering technologies might affect data consistency over the life of the indicator is not fully understood.

## Data Sources

The ACE Index data (Figure 1) came from the National Oceanic and Atmospheric Administration's Climate Prediction Center, and are available online at: [www.cpc.noaa.gov/products/outlooks/background\\_information.shtml](http://www.cpc.noaa.gov/products/outlooks/background_information.shtml). Values for the PDI have been calculated by Kerry Emanuel at the Massachusetts Institute of Technology. Both indices are based on wind speed measurements compiled by the National Oceanic and Atmospheric Administration.