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Tornadoes: Forecasting, Detection, and Communication

Tornadoes are narrow, violently rotating columns of air, connecting the base of a thunderstorm to the ground. They affect communities across the United States every year and can cause fatalities and injuries, destroy property and crops, and disrupt businesses. A May 2025 weather system produced over 90 reported tornadoes (**Figure 1**), high winds, and large hail and caused multiple deaths and injuries across the Midwest and Southeast. The National Oceanic and Atmospheric Administration (NOAA) is the primary civilian federal agency with authority to issue severe weather forecasts and warnings. Congress may debate whether to direct the agency to take additional actions related to tornado forecasting, detection, and communication in light of recent and potential future storms.

Exactly how and why tornadoes form is not completely understood. Tornado formation is believed to be dictated mainly by conditions in and around thunderstorms with well-defined circulation. Tornadoes have been reported on all continents except Antarctica. They are common in North America, particularly in the United States, which reports approximately 1,200 tornadoes per year dating back to the 1950s. Tornadoes occur across the United States but form frequently in three regions: (1) the Southern Plains (e.g., Texas, Oklahoma, Kansas), (2) the Gulf Coast (e.g., Alabama, Florida, Louisiana, Mississippi), and (3) the Northern Plains and upper Midwest (e.g., North and South Dakota, Nebraska, Iowa, Minnesota). Although tornadoes can form at any time, they occur mostly during spring and summer and usually in the late afternoon or early evening.

Classification

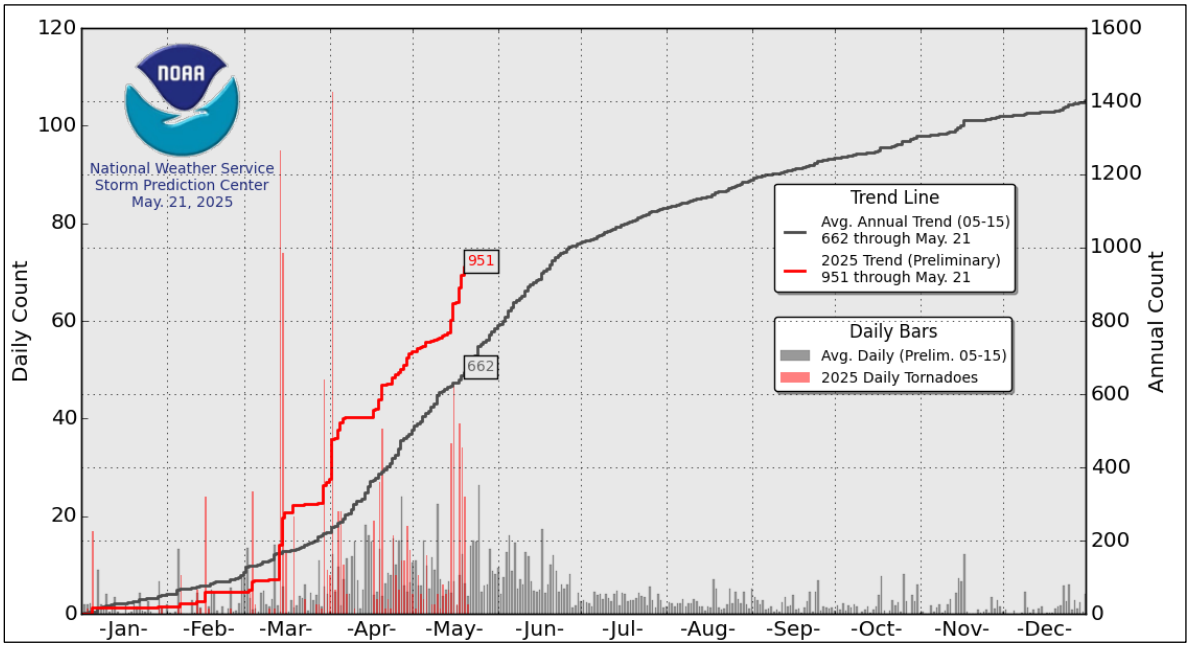
Experts estimate the strength or wind speed of a tornado by examining the damage it caused rather than by measuring actual wind speeds during an event. Damage is estimated using the enhanced Fujita-scale or EF-scale (**Table 1**).

Table 1. Enhanced Fujita-Scale

EF Number	3-Second Gust (mph)
EF-0	65-85
EF-1	86-110
EF-2	111-135
EF-3	136-165
EF-4	166-200
EF-5	Over 200

Source: NOAA, Storm Prediction Center (SPC), "Enhanced F Scale for Tornado Damage."
Notes: EF = enhanced Fujita. The EF-scale is a set of 3-second wind gust estimates at the point of damage, not a real-time observed measurement.

Figure 1. U.S. Tornadoes Daily Count and Running Annual Trend (as of May 21, 2025)



Source: NOAA, Storm Prediction Center (SPC), "Daily Counts and Annual Running Trend," May 21, 2025.
Notes: The red color denotes the 2025 U.S. daily numbers (bars) and "trend" or total number of preliminary tornadoes (line). The gray color denotes the 2005-2015 average daily numbers (bars) and annual trend (line). *Preliminary tornadoes* are tornadoes observed or reported from a variety of sources. SPC and local weather forecast offices analyze preliminary tornado reports to produce a final number (NOAA, National Centers for Environmental Information, "Index-Tornado Count").

The EF-scale uses eight levels of damage (e.g., beginning of visible damage to complete destruction) to various structures and trees. EF-0 to EF-2 tornadoes are most frequently reported in the U.S.

Forecasting, Detection, and Communication

The Secretary of Commerce, acting through NOAA's Administrator, is required to forecast weather and issue storm warnings (15 U.S.C. §313), including tornado forecasts and warnings. NOAA's National Weather Service (NWS) provides these weather, water, and climate forecasts and warnings for the United States and its territories, adjacent waters, and ocean areas. Several other NOAA programs, including the Office of Oceanic and Atmospheric Research's National Severe Storms Laboratory, focus on tornado research to improve observations, modeling, and instruments, among other activities.

Forecasting and Detection

The NWS Storm Prediction Center (SPC) and local weather forecast offices (WFOs) each have roles in tornado forecasting and detection. SPC forecasters use weather observations and numerical weather prediction and *ensemble models* (i.e., running several models at one time) to determine if atmospheric conditions may lead to the formation of severe weather. SPC issues three-day forecasts (*convective outlooks*) on a daily basis and analyses of the next six hours (*mesoscale discussions*) for severe weather potential. SPC issues a tornado watch if conditions favorable for either multiple tornadoes or a single intense tornado continue to develop; the watch typically lasts six to eight hours. SPC disseminates tornado watches to the public, emergency managers, storm spotters, broadcast media, and local WFOs and aims to issue watches at least two hours before the first tornado.

WFO forecasters and storm spotters look for certain storm features, such as the *forward* or *rear flank downdraft* (**Figure 2**), and particular patterns in Doppler radar images, such as the *tornadic vortex signature* (a region of intense concentrated rotation) to identify tornadoes.

Figure 2. Selected Components of Certain Thunderstorms

Source: NOAA, NWS, "The Supercell Pt. 2."

Notes: A *forward flank downdraft* is the leading part of a supercell storm, with most of the heavy precipitation. A *rear flank downdraft* is a region of dry air sinking on the back side of, and wrapping around, a storm (NOAA, NWS, "Field Guide Glossary").

WFOs issue tornado warnings when a tornado has been sighted or indicated by weather radar. Warnings contain language about areas at risk, time frames, specific hazards, and recommended safety precautions for those at risk.

Communication

NOAA communicates tornado warnings to the public through outdoor sirens, local and cable television and radio stations, cell phone applications, Wireless Emergency Alerts, NOAA Weather Radio All Hazards (NWR), and the federal Emergency Alert System and Integrated Public Alert and Warning System.

Congressional Considerations

Congress may continue to consider whether to maintain or otherwise change NOAA's role in forecasting, detection, and communication of tornadoes in certain ways. For example, one bill in the 119th Congress (S. 258) would evaluate the EF-scale; require a plan for use of "warn-on-forecasts" (an experimental project that relies on modeling and forecasts, rather than observations, to issue tornado warnings); amend NOAA's VORTEX-USA tornado program to "rapidly" improve tornado forecasts and warnings, and support additional physical and social science research. Some Members in previous Congresses have also introduced legislation and advocated for funding for other activities related to tornadoes, including next-generation radar and weather forecasting.

Congress may consider whether—and, if so, how—NOAA should study outstanding scientific questions. These include whether the number of tornadoes in the United States has increased over time, whether the timing and seasonality of tornadoes has changed, and whether climate change has impacted, or may impact, tornado frequency or intensity overall or in certain circumstances. For example, it is not clear whether tornadoes are occurring more frequently or whether they are being reported more often as a function of better detection, greater media coverage and verification efforts, a growing population, and the advent of cell phone cameras.

In addition, Congress may debate whether to conduct oversight of, reverse, amend, codify in statute, or take no action on changes the Trump Administration has made or proposed to federal agency staffing and funding across NOAA. For example, some news sources have reported that several NWS local WFOs no longer have 24-hour meteorologist coverage. The changes have been a part of efforts to decrease government spending; the effects of these changes on the agency are still unclear. Some current and former meteorologists and NWS directors have warned that such changes may impact NOAA's ability to forecast, detect, and communicate about impending tornadoes.

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