



# NOAA Knows... Tornado Forecasting and Warnings

Response Includes Weather, Research, Satellites,  
Oceans and NOAA Corps Offices



Each year, the United States experiences approximately 1,300 tornadoes. No state is invulnerable to the twisting, destructive winds that emanate from dark thunderstorms. Under the proper conditions, tornadoes can grow to more than one mile wide and can travel up to 70 miles per hour.

NOAA has in place a multifaceted tornado early warning system that includes general area outlooks up to eight days in advance and that gives individual cities and towns an average of 14 minutes warning before the potentially deadly tornadoes finally touch the ground.

Through a tremendous investment in research, observing systems and forecasting technology, [National Weather Service](#) (NWS) issues more than 1,000 watches and nearly 30,000 warnings for severe storms and tornadoes each year. Advances in research and technology have increased the average warning lead time from only five minutes in the early 1990s to 14 minutes in 2010, thereby giving people and communities more

time to seek shelter and secure property. Watches and warnings are credited with significantly reducing loss of life and limiting the high costs of property damage.



Several organizations within NOAA are dedicated to protecting life and property by using cutting-edge scientific research to improve severe weather forecasts and warnings.

## NWS Storm Prediction Center

The [NWS Storm Prediction Center](#) (SPC) in Norman, Okla., is responsible for hazardous weather forecasting across the contiguous United States and provides short- to medium-range guidance and tornado and severe thunderstorm watch products. SPC forecasters constantly evaluate the potential for dangerous and economically disruptive weather events, from tornadoes, large hail and dangerous fire weather conditions to everyday thunderstorms.

Every tornado and severe thunderstorm watch issued in the United States originates at the SPC. The SPC issues watches when short-term conditions appear supportive of widespread thunderstorms capable of producing large hail, high winds and/or dangerous tornadoes. Each watch is discussed and refined in partnership with local National Weather Service forecast offices to meet local community needs. The SPC makes maximum use of observations, numerical forecast models, Doppler radar, satellite data and the best available science and technology to generate their forecasts.





In addition to working with forecast offices and other national centers within National Weather Service, the SPC collaborates with government partners including FEMA.

## NOAA's Satellite and Information Service

NOAA's [Satellite and Information Service](#) operates two types of spacecraft: geostationary satellites (GOES), which hover 22,300 miles above the equator, and polar orbiting environmental satellites (POES), which circle the globe every 102 minutes from 517 miles above the Earth's surface. These "eyes in the sky" track the development of severe weather and are the backbone of NOAA's life-saving forecasts.

POES data track the subtle changes in the environment that can trigger potentially deadly weather

conditions, from tornadoes to tropical storms. The spacecraft feature a data collection system that relays a wide range of environmental observations from sensors around the world — from stream gauge and sea-level



readings to the migration patterns of wildlife tagged with transmitters — that help scientists and meteorologists stay on top of developing trends. POES data are complemented by data from GOES, which constantly take images and measurements of severe weather in the Western Hemisphere, including storms headed toward the United States.

## National Weather Service Forecast Offices

National Weather Service Weather Forecast Offices (WFOs) play a vital role in issuing severe weather forecasts and warnings. The 122 WFOs across the country narrow the threats by focusing on current and evolving weather conditions for their assigned region. Using advanced Doppler radars, trained storm spotters, reports from the general public and their knowledge of the local area, meteorologists at the WFOs issue tornado and severe thunderstorm warnings to alert the public of the imminent threat of severe weather and to take cover.

Meteorologists at the WFOs also provide direct decision support services to core partners in emergency management and the broadcast media. National Weather Service records about 26,000 severe weather reports each year. Current weather watches and warnings from local forecast offices are available online at [www.weather.gov](http://www.weather.gov).



## NOAA's National Severe Storms Laboratory (NSSL)

The [National Severe Storms Laboratory](#), part of NOAA's Office of Oceanic and Atmospheric Research, conducts leading-edge research in weather radar, the thunderstorm lifecycle process, severe storm forecasts and warnings and hydrometeorology. Established in 1964, NSSL is the only federally supported laboratory focused on severe weather.

The lab's scientists and staff are committed to observing, understanding and predicting severe weather in ways that will assist National Weather Service forecasters and federal, university and private sector partners in saving lives and reducing property damage.

NOAA's [Hazardous Weather Testbed](#) in Norman, Okla., emerged from the mutual interests of forecasters from the SPC and researchers from NSSL, and was inspired by the culture of collaboration that already existed between the two organizations as well as the National Weather Service Norman forecast office.

The Testbed's basic and applied research focuses on understanding severe weather processes, developing weather observation technology, and improving forecast tools, with emphasis on [weather radar](#), [hydrometeorology](#), and [forecast and warning improvements](#). This collaboration increases the understanding of hazardous weather environments across the United States and the world, and promotes the infusion of new science and technology into SPC forecast operations.



## TORNADO EVENT CASE STUDY: NOAA-wide response to the April 2011 tornado outbreak

### I. Before and during the storms

April 27 and April 28, 2011, will go on record as the deadliest two-day period for tornadoes since 1936. More than 300 people were killed during the outbreak of tornadoes that began during the early morning of April 27 and ended during the early morning hours of April 28.

Five days before the powerful storm system tore through six states, NOAA's polar-orbiting satellites (POES) alerted forecasters at the agency's Storm Prediction Center (SPC) of the impending danger.

Instruments onboard POES collected high-resolution imagery, atmospheric soundings and other valuable data were fed into NOAA's numerical prediction models used to develop outlooks several days in advance of severe weather.

In the week leading up to the outbreak, SPC's Day 5 Outlook

(issued Saturday, April 23) and Day 4 Outlook (issued on Sunday, April 24) underscored the potential for tornadoes. By issuing a High Risk Outlook at midnight prior to the event, SPC elevated the risk to the highest level. On the day of the outbreak, SPC issued 28 tornado watches, alerting the public of the potential for tornadoes within the next several hours — urging people to stay informed.

More than 95 percent of the tornadoes that day occurred within a tornado watch. A *watch* means severe weather is possible during the next few hours, while a *warning* indicates that severe weather has been observed, or is expected soon. Learn more about watches and warnings by visiting <http://www.spc.noaa.gov/faq/#2.4>.

National Weather Service Weather Forecast Offices (WFOs) in the area impacted also began alerting emergency managers and the public of the threat of tornadoes days before the outbreak. Hazardous Weather

Outlooks from these offices included the “potential for strong long-track tornadoes.” During the event, WFOs issued hundreds of tornado and severe thunderstorms warnings, as well as numerous flash flood warnings.

Preliminary estimates for this event indicate the average lead time for tornado warnings was approximately 24 minutes, and more than 85 percent of all tornadoes were under a warning. The accuracy and timeliness of the tornado warnings for this outbreak far exceeded national averages.

National Weather Service Regional Headquarters offices supported the field offices by briefing FEMA and other federal partners and provided numerous media interviews to national, regional and local news outlets from around the country. Due to the large area affected and extreme intensity of the April 27–28 tornado outbreak, the most impacted WFOs in Alabama, Mississippi and Tennessee received temporary, supplemental staffing from other WFOs and regional offices.

### II. In the aftermath

After tornadoes pass through an area, NWS WFOs provide substantial decision support to local, state and federal responders for search and rescue and other response and recovery operations. The WFOs are also responsible for surveying the damage on the ground and provide expert analysis on the societal impacts of individual tornadoes.



On-the-scene reports and aerial reconnaissance help investigators determine the category of the tornado that struck during this event. Meteorologists use the Enhanced Fujita (EF) Scale to rate tornado strength and wind speeds. Categories range from EF0 (weakest) to EF5 (strongest). Visit <http://www.spc.noaa.gov/efscale> to learn more.

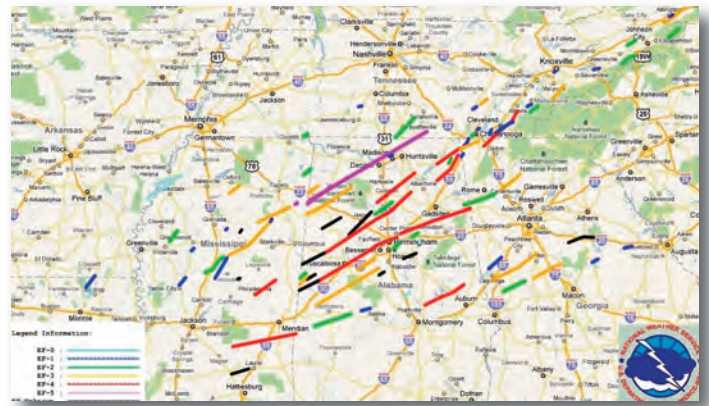
The day following the tornado event, NSSL provided an image of the tornado rotation tracks that could be overlaid on a Google Earth image. Forecasters at the WFO in Birmingham, Ala., could zoom in on specific neighborhoods to help them coordinate where damage surveys should be conducted and what roads they should take to get there.

NOAA's National Geodetic Survey (NGS), working with NOAA's Office of Marine and Aviation Operations, provides aerial photographs of areas impacted by natural disasters, such as tornadoes and hurricanes, as part of their ongoing responsibilities.



These before and after images of impacted areas assist federal, state and local managers with search and rescue operations, the routing of personnel and machinery, recovery effort plans and more accurate damage assessment.

The aerial photography offers the impacted public, who may be temporarily restricted from visiting the region, an opportunity to view their property and begin work with FEMA and others to begin recovery.



Tornado tracks from April 2011 outbreak.

NOAA's Office of Marine and Aviation Operations operates, manages and maintains the King Air 350CER aircraft that was used for NGS's aerial damage surveys following the April 27–28 tornado outbreak. The NOAA twin-engine turboprop is equipped with specialized remote-sensing equipment that captured thousands of photographs at a high resolution of 17 centimeters-per-pixel. The aircraft collected images of tornado-stricken areas from an altitude of 5,000 feet.

NGS quality-checked all the aerial imagery and created a mosaic of photos overlaid on a map of the region. To view the images, please visit: [http://ngs.woc.noaa.gov/storms/apr11\\_tornado/](http://ngs.woc.noaa.gov/storms/apr11_tornado/).

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NOAA's cutting-edge tornado warning system — a critical component of the agency's larger portfolio of weather satellites and advanced forecast and warning systems — in combination with ground and aerial damage assessments are essential to America's safety, security and economic prosperity.

For this and other severe weather events and natural disasters, NOAA has consistently demonstrated its ability to work across all parts of the agency and in concert with federal, state and local partners to produce timely, high-quality information and services on which decision-makers, emergency managers and the public rely. Please visit [www.noaa.gov](http://www.noaa.gov) and our Facebook page, [www.facebook.com/usnoaagov](http://www.facebook.com/usnoaagov), to learn more. 