



# PERSPECTIVES

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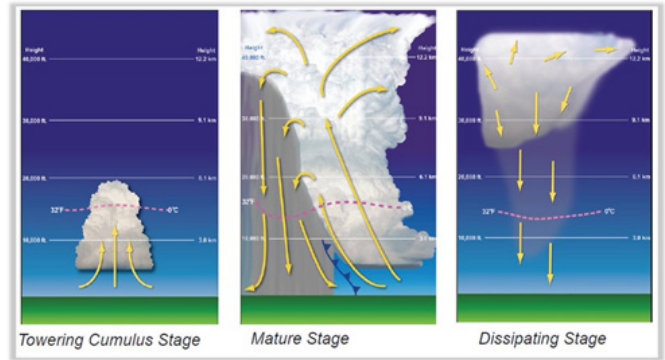
## **Derecho, Downburst, or Bow Echo? Thunderstorm Wind Events Explained**

Our perspectives feature the viewpoints of our subject matter experts on current topics and emerging trends.

## INTRODUCTION

Wind events are generally characterized as straight-line winds; however, some are isolated and short-lived, while others are not. But what’s the difference?

The answer often lies within the presentation of the thunderstorm itself. For example, ordinary afternoon thunderstorms can result in isolated, short-lived downbursts, but generally do not affect a wide area. However, elongated thunderstorm complexes driven by rigorous atmospheric dynamics can travel hundreds of miles, resulting in a wide swath of damaging wind gusts.



**Figure 2** - Development and lifecycle of a thunderstorm (Source: NOAA).



**Figure 1** - A thunderstorm shelf cloud associated with a gust front (Source: Brittney Misialek via NOAA SPC).

## WHAT IS A DOWNBURST?

Downbursts are powerful wind events that are caused by downward-moving air from a cumulus-type cloud.<sup>1,2</sup> These strong downdrafts occur when a thunderstorm (or rain shower) can no longer hold the enormous amount of water weight suspended in the air overhead. This weight plummets out of the sky, gaining momentum as it falls, and displaces the air beneath it. Added features like dry air beneath the storm cloud can result in evaporating some (or all) of this falling precipitation, enhancing the downdraft speed by replacing the evaporated water molecules with heavier nitrogen and oxygen molecules.<sup>3</sup>



**Figure 3** - A downburst (Source: [https://www.weather.gov/bmx/outreach\\_microbursts](https://www.weather.gov/bmx/outreach_microbursts)).

## THUNDERSTORM WINDS

To understand thunderstorm winds, it is important to understand thunderstorms themselves. Thunderstorms occur in cumulonimbus clouds. Cumulonimbus clouds form due to humid, unstable, rising air. The rising air condenses into a cloud containing liquid water, hail, and ice. The concentration and cohabitation of water and ice within the thunderstorm produces lighting, which differentiates a thunderstorm from a rain shower. However, at some point during the thunderstorm’s lifecycle, it is no longer able to hold the massive weight of its contents suspended in the air.

<sup>1</sup> <https://glossary.ametsoc.org/wiki/Downburst>

<sup>2</sup> <https://glossary.ametsoc.org/wiki/Downdraft>

<sup>3</sup> <https://www.weather.gov/lmk/downburst>

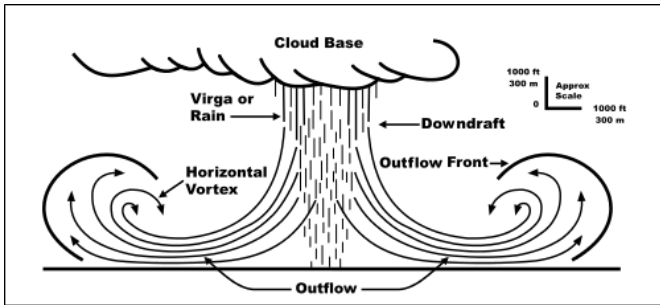


Figure 4 - Diagram of a downburst (Source: US Federal Aviation Administration).

Downbursts can result in powerful straight-line winds—in some cases exceeding those of weak tornadoes. While downbursts are usually wider than tornadoes, they are still narrow in comparison to other thunderstorm wind events. A microburst, by definition, is less than or equal to four kilometers in width.<sup>4</sup>

Downbursts can also produce gust fronts, which travel outward from a storm (sometimes dozens of miles) and can be a hazard to both life and property. Dust storms, for example, often form along gust fronts.

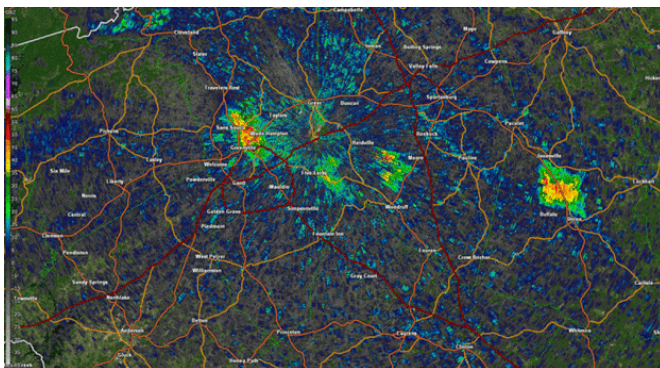


Figure 5 - A thunderstorm near Greenville, South Carolina resulting in a downburst, with gust fronts emanating both north and southwest of the storm (Source: NOAA Archives/Gibson Ridge Radar Software).

## WHAT IS A BOW ECHO?

A bow echo is a bowed, bulged (or arched) thunderstorm presentation, sometimes embedded within a larger line of

thunderstorms such as squall lines. Bow echoes have a kidney bean (or backward “C”) shape and are typically associated with an axis of enhanced straight-line winds that can translate to damaging wind gusts at the surface which spread horizontally and repeatedly enforce the bowing structure.<sup>5,6</sup> Simply put, a bow echo is simply a bowed linear thunderstorm event in which the highest winds are often observed.

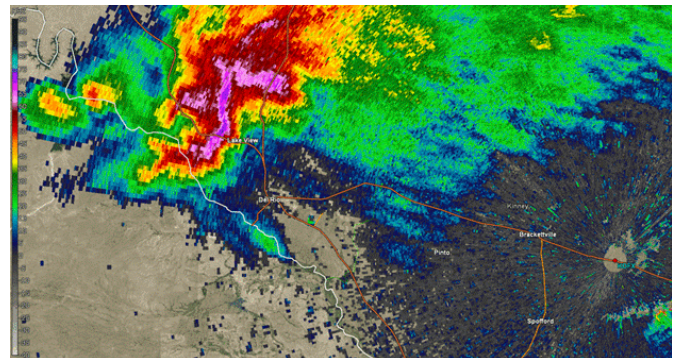


Figure 6 - A severe thunderstorm on February 22, 2016, in southwest Texas transitioning into a bow-echo presentation (Source: NOAA Archives/Gibson Ridge Radar Software).

Bow echoes result in powerful wind gusts due to several factors. Downburst winds are common within bow echoes, and tornadoes can also form within the storm, especially on the northern periphery known as the “bookend vortex.” Additionally, in a mature bow echo, strong mid-tropospheric winds (known as the rear-inflow jet)<sup>7</sup> will cascade downward behind the bow echo resulting in the momentum transfer of high winds aloft to the low levels, if not the ground.

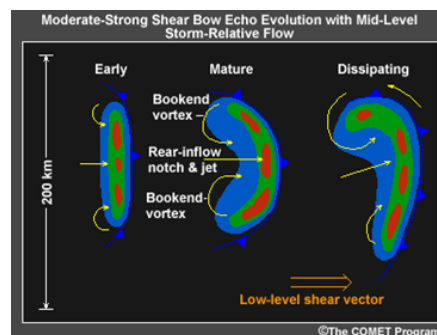


Figure 7 - Schematic of a typical bow echo (Source: UCAR COMET Program).

<sup>4</sup> <https://glossary.ametsoc.org/wiki/Microburst>

<sup>5</sup> <https://www.noaa.gov/jetstream/derechos/bow-echoes>

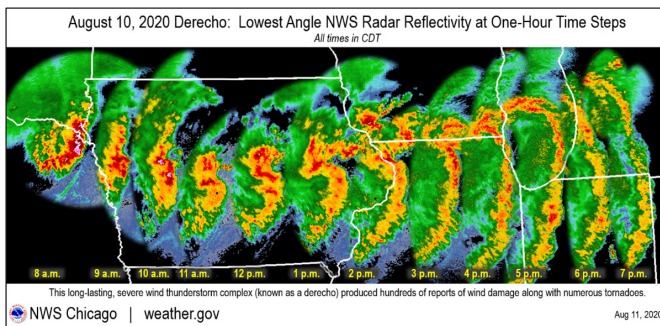
<sup>6</sup> [https://glossary.ametsoc.org/wiki/Bow\\_echo](https://glossary.ametsoc.org/wiki/Bow_echo)

<sup>7</sup> [https://glossary.ametsoc.org/wiki/Rear-inflow\\_jet](https://glossary.ametsoc.org/wiki/Rear-inflow_jet)

## WHAT IS A DERECHO?

A derecho (pronounced “deh-REY-cho”) is a widespread, long-lived windstorm associated with thunderstorm squall lines and quasi-linear convective systems (QLCS).<sup>8</sup> A derecho is a bow echo, but not all bow echoes are derechos. To be classified as a derecho, the following criteria must be met:

- Widespread severe reports (wind damage or 26+ m s<sup>-1</sup> or 58+ MPH gusts) comprising the wind swath all must occur from the same mesoscale convective system (MCS).
- The parent MCS must be at least 100 km (over 60 miles) long and last for at least 3 hours.
- All reports in the wind swath must occur in a progressive sequence.
- The parent MCS forward speed is greater than the mean wind speed.
- No more than 1 hour may elapse between reports in the wind swath.
- Spatial gaps between reports in the wind swath may not exceed 200 km (125 miles).
- The wind swath must be at least 400 km (about 250 miles) long.
- At least five 33+ m s<sup>-1</sup> (75+ MPH) gust reports (measured or estimated), separated by 80 km (50 miles), must occur in the 400+ km (250+ mile) long wind swath.
- At least three measured 33+ m s<sup>-1</sup> (75+ MPH) gust reports, separated by 80 km (50 miles), are required in the wind swath.



**Figure 8** - August 10, 2020, radar overview (Source: NOAA/ NWS Chicago).

A derecho in Iowa and northern Illinois on August 10, 2020, resulted in \$11.5 billion worth of damage, making it the costliest known non-tornadic thunderstorm wind

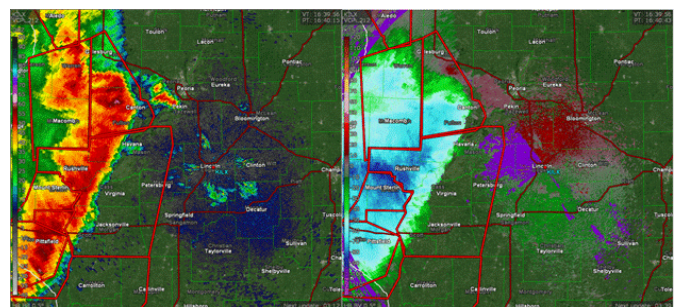
event in modern United States history, falling short of only one other severe thunderstorm event—the April 2011 tornado outbreak in the southeastern U.S. Over one million people lost power, some for weeks. Severe crop damage also occurred. Derecho events pose a significant challenge to forecasting, as the atmospheric variables required for a derecho to occur often have a rapidly changing domino-effect pattern. Thus, it is important to routinely check the weather forecast, especially during storm season.



**Figure 9** - National Weather Service Storm Prediction Center Outlooks on the morning of August 10, 2020, starting with a marginal risk around 1 AM CDT and quickly upgrading through the morning as derecho conditions became apparent (Source: NOAA/SPC Archives).

## CONCLUSION

Thunderstorm wind events are diverse and complex. Some thunderstorms produce several different types of wind events within their lifecycle and can merge with nearby thunderstorms to form an even larger storm complex capable of widespread extreme winds, such as a derecho. While not discussed within this article, tornadoes can also form in thunderstorms, resulting in additional wind-related damage and safety concerns.



**Figure 10** - Base Reflectivity (left) and Base Velocity (right) radar imagery of a derecho on June 29, 2023, in west-central Illinois (Source: NOAA Archives/Gibson Ridge Radar Software).

<sup>8</sup> <https://www.spc.noaa.gov/misc/AbtDerechos/derechofacts.htm>

<sup>9</sup> <https://www.weather.gov/lot/2020aug10>

<sup>10</sup> NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023). <https://www.ncei.noaa.gov/access/billions/>, DOI: 10.25921/stkw-7w73

Winds are not only associated with thunderstorms, such as high winds during tropical storms and hurricanes, although even these events often exhibit both downbursts and tornadoes. Furthermore, high winds can also accompany strong cold fronts which sweep across a continent, they can be subjected to mountain down-sloping effects (such as Chinook winds and Santa Ana winds), and even appear in the form of hazardous dust devils on hot, sunny afternoons in desert climates.

## Know Your Thunderstorm Risks with Expert Forensic Meteorologists

American Meteorological Society Certified Consulting Meteorologists (CCMs) can assist global clients in understanding their weather risks, gaining a clear picture of the weather event following a loss, and mitigating future losses.

## ACKNOWLEDGMENTS

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