

## **Midwest to Northeast Major Winter Storm**

**1/30 - 2/2 2021**

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### **Meteorological Overview:**

A slow moving and major nor'easter impacted much of the northeast and north central parts of the country from late January into early February 2021. While the extreme snow (greater than 30 inches) was confined to a narrow corridor of eastern Pennsylvania and northern New Jersey, the overall impacts from this event were far reaching. Heavy snow occurred from Minnesota to North Carolina, and then up the eastern seaboard to Maine. At one point approximately 90 million people were under winter weather advisories or winter storm watches/warnings.

The system responsible for this event began across the Pacific Ocean as an extratropical low pressure which moved onshore and weakened in late January. However, the residual shortwave energy moved across the Rockies on January 30 and began to close off at 500mb atop the Central Plains and into the Midwest on January 31. This closed low then merged into a larger gyre centered over the Ohio Valley by February 1, which then drifted slowly eastward through February 2 before finally filling and ejecting northeast into Canada on the 3rd.

Beneath the first shortwave moving across the Midwest at the end of January, surface low pressure developed across Kansas in response to height falls/positive vorticity advection and slowly increasing diffluence within the left-front quadrant of an upper jet streak diving southeast from the Northern Plains. As this low moved eastward to Indiana January 31, a warm front lengthened to its east into the Appalachians and Mid-Atlantic states. Robust warm air advection sourced from the Gulf of Mexico lifted northward along this warm front, rising isentropically most intensely along the 290K surface atop cold surface high pressure. This led to an increasing shield of precipitation, with rain, snow, and freezing rain spreading across the Midwest and Ohio Valley. At the same time, rich theta-e advection wrapping northward within a developing TROWAL north of the 700mb low on the 31st led to heavy snow rates in excess of 1"/hr near Chicago.

In addition to the midwest snow, intensifying warm air advection along the warm front combined with mid-level height falls and broad divergence ahead of the closed low lead to precipitation spreading northeastward across the Southern Appalachians and towards the Mid-Atlantic January 31st to February 1st.

This primary low began to weaken as it moved eastward into the Ohio Valley. This was due to its parent shortwave becoming absorbed into the larger closed low causing it to become vertically stacked, but also in response to more significant deep layer lift shunting to the east. This more robust lift was in response to rapidly strengthening upper jet streaks coupling downstream of the mid-level trough axis, leaving intense upper diffluence over the Mid-Atlantic states and acting upon the low-level baroclinic zone associated with the eastward extending warm front. This

intense synoptic ascent led to a rapidly strengthening surface low off the Virginia coast February 1-2, and this secondary low would become the primary driver of winter weather for this event.

As the secondary low off Virginia became dominant, forcing became even more intense across the Mid-Atlantic and New England. Initially, precipitation was driven primarily by warm air advection emanating out of the Gulf of Mexico. However, as the surface low matured into a nor'easter, large scale ascent became enhanced by mesoscale forcing including the overlap of a warm conveyor belt and cold conveyor belt which produced an ideal setup for heavy snow bands across the northern Mid-Atlantic and into New England. Additionally, robust deformation and intensifying mid-level frontogenesis on the back side of the system helped to drive intense upward vertical motion through the dendritic growth zone (DGZ), and snowfall rates of 2-3"/hr occurred for many hours across this region as the surface low moved very slowly northeastward beneath the upper trough. These heavy snow rates along with strengthening winds due to the tightening pressure gradient near the surface low led to blizzard conditions near New York City.

Farther south, a strong dry slot rotated northeastward into the strengthening low pressure. This rapid decrease of moisture within the DGZ negated ice crystal growth which led to a prolonged period of light freezing rain or snow grains across this region. This limited the snowfall accumulations for the southern portions of the I-95 megalopolis from Philadelphia to Washington, D.C., but also led to an increase in freezing rain accretion.

As the surface low lifted northeast February 2, it began to fill beneath the vertically stacked upper low, with a tertiary low developing near the Gulf of Maine. This last feature helped to increase snowfall across New England on the 2nd, while the large scale upper low maintained enough forcing for periods of moderate to heavy snow to linger as far southwest as Virginia as late as the 2nd, 3 days after the snow began.

### **Impacts:**

Widespread heavy snow fell from the primary low moving through the Midwest January 30 to February 1. More than 4" accumulated in parts of Minnesota and Iowa, as well as in a swath from Wisconsin through Ohio. The heaviest snow in this region was from Milwaukee, WI, to Chicago, IL, to Fort Bend, IN where widespread 8+ " of snow occurred. Snowfall rates eclipsed 1"/hr at times, and thunder was reported at several observing sites. Chicago O'hare airport received 10.8" of snow, Midway accumulated 11.3", and more than 100 flights were cancelled out of Chicago during the storm. The highest snowfall in the Midwest occurred in the suburbs of Chicago and Milwaukee where lake enhancement led to isolated storm totals in excess of 12".

<p>Additionally, the snowfall that developed along the warm front prior to secondary low development accumulated 4-8" in the Southern Appalachians and Virginia including 6" at the Roanoke, VA airport, and nearly 8" at Grandfather Mountain, NC. Virginia state police responded to 270 crashes during the event.

Impacts from the secondary low and subsequent nor'easter in the Mid-Atlantic northeast were much more significant. Snowfall accumulated to more than 12" across an expansive area of the Mid-Atlantic and Northeast from western MD through Pennsylvania, New Jersey, New York, and all of New England. Maximum snowfall was much greater. The highest totals eclipsed 3 feet, including 36.9" at Mount Pocono, PA, and 36.1" in Nazareth, PA. Other extreme totals included 35.5" at Mount Arlington, NJ, 27.3" at Allentown, PA, the second highest all-time there, 25.6" at Fishkill, NY, 24.0" in Lowell, MA, 22.1" in Terra Alta, WV, and 20.1 in Sabillasville, MD.

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<p>While the heaviest snow stayed mostly just northwest of the I-95 corridor, the major cities also received significant snowfall. 17.4" accumulated at Central Park, NY, the highest total in 5 years. JFK, Laganardia, and Newark airports all received more than 12" of snowfall, while Islip measured 16" and officially recorded a blizzard with visibility less than ¼ mile and winds of 35 mph for more than 3 consecutive hours. Philadelphia measured 7.9" and Baltimore received 4.0". Boston, MA only received 1.2" due to onshore winds which caused warming, but the snowfall gradient just outside the city to the W/NW was more than 1" per mile.

Widespread extreme impacts due to the heavy snow and wind occurred during this event. A state of emergency was declared in Pennsylvania, New Jersey, and New York, with snow emergencies raised in Massachusetts. In Pennsylvania, the DOT lowered speed limits across most of the interstates during the storm, bus transportation was halted in some of the cities, and more than 150 flights were cancelled out of Philadelphia International Airport. New Jersey suspended all mass transit February 1 and the DOT enacted travel restrictions. Despite that, the New Jersey state police responded to 660 crashes on area roadways. Additionally, New Jersey shut down all 6 of their COVID mass-vaccination sites on February 1. New York also closed their COVID mass-vaccination sites February 1-2, halted all New York Mass Transit buses, and suspended subway service. Travel restrictions were enforced on the New York State Thruway, and all roads into New York City were closed to non-essential travel. All commercial flights at JFK, Newark, and Laganardia airports were cancelled on February 1, with approximately 50% of flights still cancelled February 2. Amtrak suspended all train service between New York, Albany, and Boston during the height of the storm.

Considerable impacts also occurred farther north into New England. Across Massachusetts, more than 4600 customers lost power due to the snow and wind, and coastal flooding inundated parts of the north and south shores. Several Massachusetts COVID mass-vaccination sites were closed for a day, although others were able to remain open with limited service. RI, however, closed all of their mass-vaccination clinics on February 1. Connecticut had to postpone their resupply of COVID vaccine, so despite their vaccination sites remaining open, appointments had to be cancelled. Bradley International Airport in Hartford had nearly all of their flights cancelled February 1, and both Bridgeport and Waterbury received official blizzard conditions. In New Hampshire, wind gusts atop Mount Washington reached 100 mph on February 2.

On the lighter side, Washington, D.C. accumulated 3.2", which was their first snowfall of greater than 0.5" since February 20, 2019, a record streak of 710 days. This led to hundreds of people donning their protective masks and organizing a massive snowball fight on the National Mall January 31.