

## **Four Corners to Great Lakes Winter Storm**

**Dec 27-30, 2019**

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### **Meteorological Overview:**

A long lasting major winter storm affected a large swath of the United States between December 27 and December 31, 2019. This event produced an axis of more than 6" of snow from the Four Corners region, through the Central and Northern Plains, and into the Great Lakes. Some locations in the Northern Plains received more than 20" of snow. Wind gusts of greater than 50 mph were reported, creating blizzard conditions in many areas. Additionally, light to moderate freezing rain accretions also occurred.

The system originated from a closed upper low which moved onshore Southern California on the 27th of December and then opened into a full latitude trough across the intermountain west on the 28th. During this evolution, a jet streak rotated around the base of the trough, placing the favorable diffluent left front quadrant overhead the Four Corners, with 40 kts of 700mb southerly flow significantly increasing available precipitable water (PWAT). The combination of the large scale ascent through diffluence and height falls in the region of high column moisture produced heavy snowfall across portions of Arizona, New Mexico, Utah, and Colorado. The heaviest snow was confined to the terrain of these states, but most of the lower elevation valleys also received light accumulating snow.

As the upper trough ejected northeastward on the 29th, it again deepened into a negatively tilted trough and closed off across the Northern Plains. Beneath this feature, lee surface cyclogenesis developed in eastern Colorado, and this surface low lifted rapidly to the northeast towards Iowa. As the low moved northeast, it deepened rapidly in response to continued height falls aloft and increased coupling of 130-150kt jet streaks. Ahead of the surface low, southerly 850-700mb flow drew anomalously high PWAT air northward, with integrated vapor transport (IVT) rising to +2 standard deviations above the climatological mean across the Northern Plains during the 29th. As this warm moist air lifted northward, a strong TROWAL developed which allowed moisture to wrap cyclonically around the surface low, with coincident deformation within the mid-levels aiding in strong ascent to produce heavy snowfall NW of the 850mb low.

The setup became more complex into the 30th as the mid/upper level low became vertically stacked near the MN/IA/WI borders. This caused the surface low to stall, and actually retrograde briefly to the NW as it occluded to a triple point near Michigan. This allowed the TROWAL/deformation band to pivot almost in place across portions of the Dakotas into Minnesota, maintaining heavy snowfall across this area with snowfall rates reaching 1"/hr. However, as a secondary low near the triple point became dominant, it shunted the moisture supply to the initial surface feature, and heavy snow began to wind down on the 30th across the Northern Plains, but ramp up in the western Great Lakes as secondary TROWAL development and renewed mid-level deformation provided enhanced lift. The snowfall across the Great Lakes became briefly heavy on the 30th as some mesoscale banding occurred, but the overall ascent

began to wane as the jet streak position became less favorable into the 31st and the upper low finally lifted away to the northeast.

Some light to moderate snow persisted into the 31st as cold advection spawned some Lake Effect enhancement downwind of Lake Michigan, Superior, Erie, and Ontario, but duration and intensity of the snowfall was much weaker than the more strongly forced snowfall upstream earlier in the event.

Although the snow was the dominant significant weather type during this event, a narrow swath of freezing rain did occur southeast of the heavy snowfall and along the track of the 850mb low. Here, southerly warm advection caused a warm nose to develop atop persistent surface cold air. Additionally, a dry slot wrapping into the 850mb low caused a loss of saturation within the dendritic growth zone (DGZ) across portions of Minnesota, Wisconsin, and the Upper Peninsula (U.P.) of Michigan. These two features together produced light to moderate freezing rain accretions between the 28th and the 30th.

### **Impacts:**

This event produced more than 6 inches of snow atop most of the terrain from the Mogollon Rim in Arizona through the Wasatch of Utah, the San Juans, Sangre De Cristos, and Rockies of Colorado, as well as portions of the higher terrain in the vicinity of the Four Corners from the 27th-28th. As the system evolved and strengthened into the Plains and Great Lakes, a nearly continuous swath of more than 6" of snow was measured from central Nebraska into southern South Dakota, eastern North Dakota, northern Minnesota, far northern Wisconsin, and the U.P. of Michigan. Some of the highest snow amounts included 18" in Gross, NE, 15" near Roscoe, SD, 25" in Forbes, ND, 13" in Allouez, MI, and 11" in Gile, WI. The heaviest ice accretions included 0.05" in Goodland, KS, 0.13" in Greeley, NE, 0.13" in Foley, MN, 0.10" near Rhinelander, WI, and an impressive 0.35" just south of Sault Ste. Marie, MI.

In addition to the heavy snow, wind gusts of 40-60 mph created blizzard conditions across a large portion of the Plains. Whiteout conditions with near 0 visibility were reported in many locations across eastern South Dakota, North Dakota, and western Minnesota. This made travel hazardous to impossible during the height of the storm. South Dakota DOT issued a "No Travel Advised" designation for most state and county roads, and both interstate 90 and 29 were closed during the event. In North Dakota, most roads across the eastern half of the state and into the Red River Valley of Minnesota were closed, and a travel alert was in effect throughout the event. Both Grand Forks and Fargo International Airports were shut down during the blizzard.

In Minnesota, travel impacts were even more significant as the event started as light freezing rain on the 28th, leading to nearly 500 vehicle accidents, with 43 injuries and 2 fatalities. Sections of interstates across the state were closed at times during the freezing rain on the 28th, and again during the blizzard on the 29th. For the first time in 9 years the Minnesota Metro Transit suspended bus service for their entire system. Minnesota State Police advised against

all travel until the roads could be cleared, and I-94 in Western MN was closed due to stuck vehicles and whiteout conditions.

Elsewhere, I-80 was closed for about 12 hours in Nebraska due to a multiple vehicle accident and jackknifed tractor trailer blocking the road. This stranded many motorists during the overnight hours of the 30th.