

Central Rockies to Great Lakes Winter Storm

17-22 November, 2016

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Meteorological Overview:

The first significant winter storm of the 2016-17 winter season impacted nearly half of the contiguous U.S. with a duration of nearly a week. This winter storm began as a shortwave crossing the Great Basin on the evening of 16 November, 2016 (Figure 1). The wave continued traversing east through the Central Rockies on 17 November and exiting the Front Range late in the day. A surface cyclone spun up over the Central High Plains by the early morning on 18 November with cold frontogenesis developing from the surface cyclone southward through the Southern Plains. The 500 hPa low tracked northeast toward the Upper Midwest, steering the surface front from the Central Plains through the Mississippi Valley and into the Great Lakes, Ohio and Tennessee Valleys by 19 November. Warm, moist air began pooling in southern Texas late on 17 November before advecting northward into the Midwest by early morning on 18 November. A thin swath of precipitable water $\geq 1''$, from the lowest 400mb, spanned from the western Gulf of Mexico coast to the Wisconsin/northern Michigan border by the afternoon of 18 November; which was along the leading edge of the advancing cold front. Embedded maximums of 1.2-1.3'' were present over portions of the Ohio Valley, Michigan, Lake Huron and Lake Erie from 23Z 18 November to 05Z 19 November. Heavy snow fell parallel to the deformation zone; where the strongest 800-750 hPa Equivalent Potential Vorticity (-1 to -2 PVU) was present within the frontogenesis zone.

A secondary cold front moved across the Upper Great Lakes through the morning and afternoon hours as the central low pressure tracked across Ontario into central Quebec. This slowly-moving boundary continued to generate snow over portions of the Great Lakes region and Ohio Valley through late on 20 November before weakening. The primary system, which was mainly stalled over New England from 19 November into midday 20 November, progressed through New Hampshire and Maine late on 20 November and continued to advance northward through Quebec, New Brunswick and the Canadian Maritimes through the end of the event. Strong low-level convergence was present over portions the Northeast, as well as, the strongest 800-750 hPa Equivalent Potential Vorticity (-2 to -3 PVU). Cold air travelling over the length of the relatively warm waters of Lakes Erie and Ontario greatly enhanced the snowfall to areas downwind and over much of upstate New York. Light snow continued across portions of Maine after the surface front pushed offshore in association with wraparound flow from the mid-to-upper level low pressure center.

The Regional Snowfall Index (RSI) for this winter storm equated to the following: the Northern Rockies and Plains 1.549, Upper Midwest 2.538, Ohio Valley 9.958 and the Northeast 2.154. The RSI suggests that a majority of this winter storm was notable (Category 1 with a RSI of 1-3). However, for the Ohio Valley, it was a major event (Category 3 with a RSI 6-10) with a ranking of 12th place. By the time the storm diminished it had impacted an area of 786,136 square miles with a total population of 75,783,974 people

Impacts:

Due to the lengthy duration of the event, the interpolated observed snowfall analysis was split into two 72-hr periods, shown in Figure 2. The first significant winter storm of the 2016-2017 season impacted millions of people. Intense snowfall rates combined with very strong winds caused prolonged blizzard conditions along the Front Range and into the adjacent High Plains. This resulted in numerous accidents and slide-offs; which, ultimately forced closures of I-70 in Colorado and I-80 in Wyoming. Snow drifts measuring a few feet high were common across the Northern Plains and Upper Midwest. Hundreds of schools across this region were closed. Local authorities strongly advised citizens against travelling in the treacherous conditions. Dozens of flights were cancelled or delayed at Denver International Airport.

Portions of western and north-central Minnesota had widespread power outages caused by downed trees from the high winds and heavy snow. Recovery efforts by Crow Wing Power were temporarily suspended due to the dangerous conditions for their employees. According to the St. Cloud Times, Minnesota State Patrol responded to 340 crashes from across the state from Thursday night to Friday afternoon; 37 of the crashes involved injuries with two fatalities. An additional 559 vehicles spun out or slid off roadways. USA Today stated that firefighters were sent out to several traffic signals to hose off the thick accumulations from the lights in Baxter, Minnesota and at 5 intersections along Highway 371.

Snow amounts significantly increased upon crossing the Great Lakes into the Northeast and New England. Portions of upstate New York were buried in the lake-enhanced snowfall. Nearly 17,000 residences were without power on Sunday near Rochester, New York. Ultimately, area schools had late starts or cancellations the next day. Treacherous driving conditions extended to the south and east of the Great Lakes. A bus crashed and overturned on a snow-covered highway in upstate New York on Monday, injuring several students. Numerous accidents occurred over the region; resulting in another four fatalities in New Hampshire, New York and Pennsylvania.

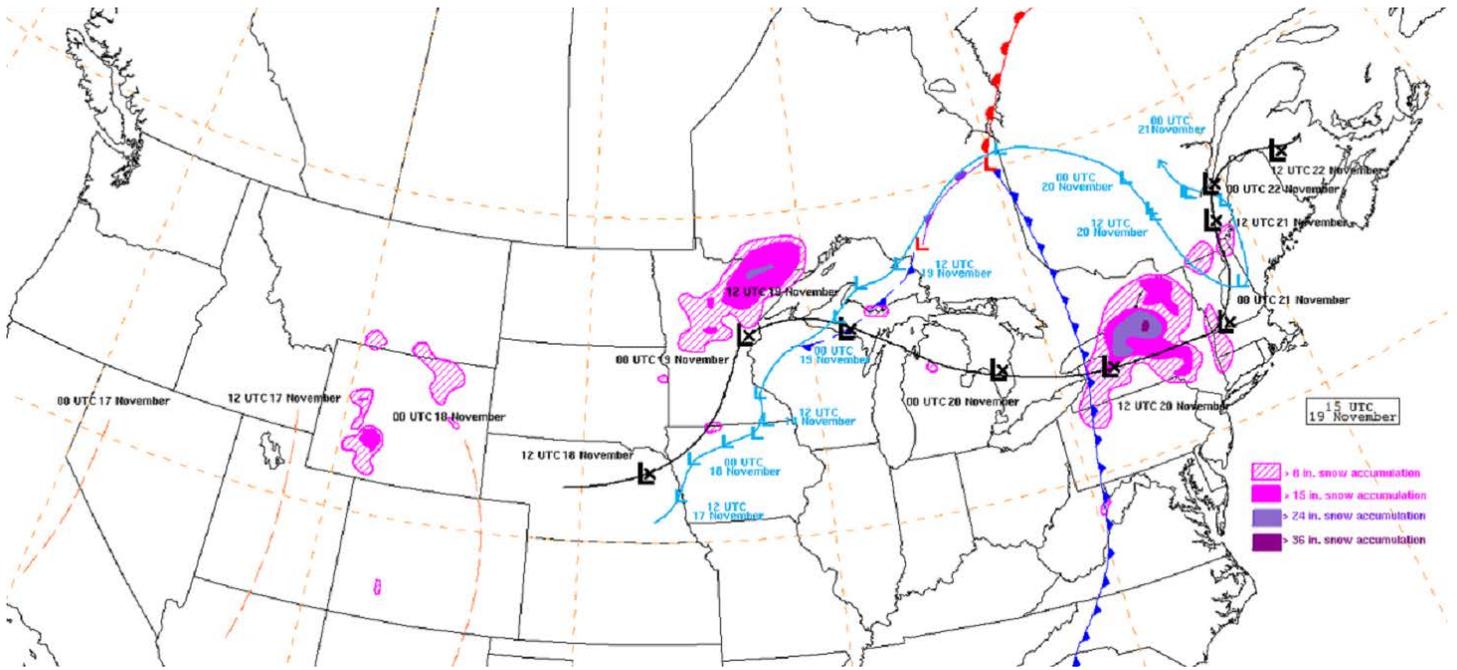


Figure 1: Surface low track (blue), 500 hPa low track (black), approximate areas of snow greater than 8 inches (fuchsia-hatched), 15 inches (fuchsia), 24 inches (slate blue), 36 inches (dark magenta) and surface fronts at 1500 UTC 19 November.

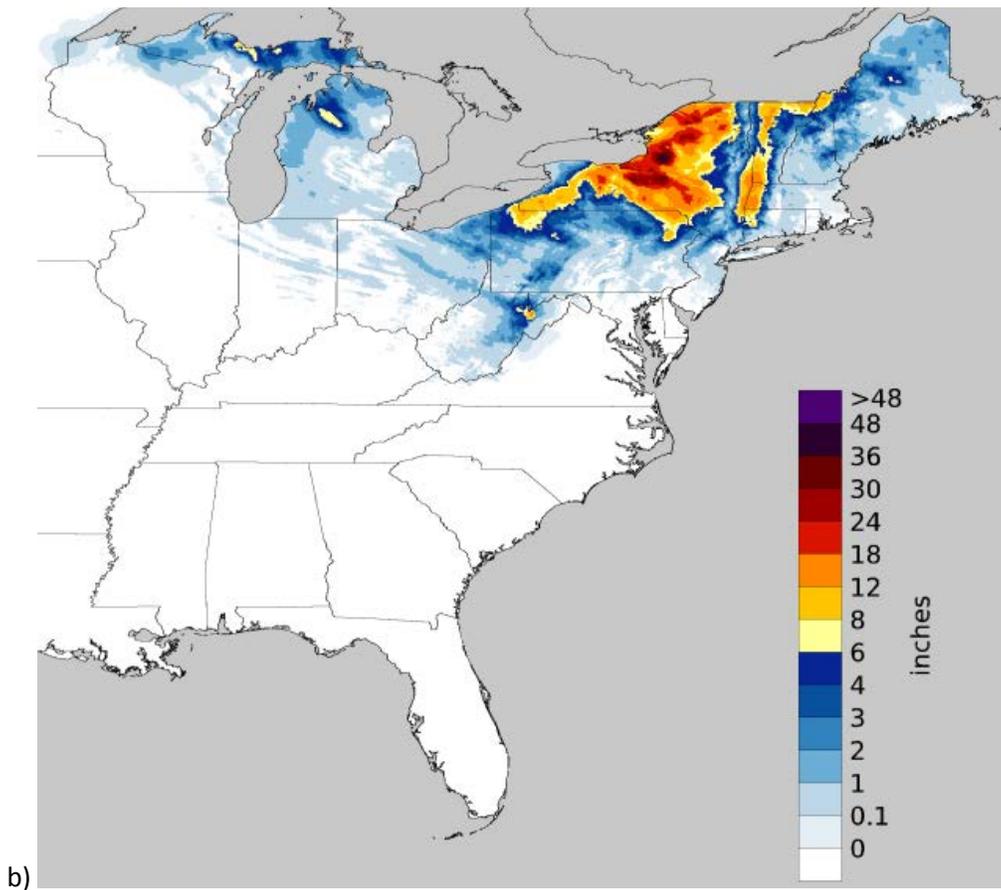
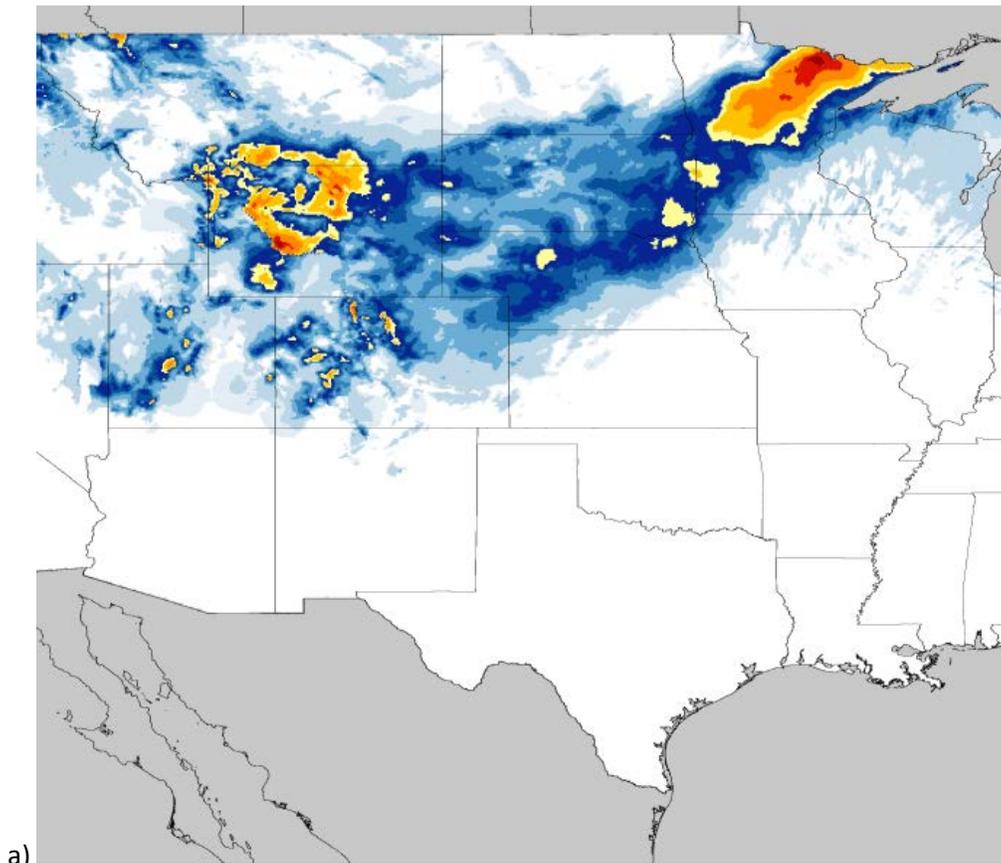


Figure 2: a) Interpolated Observed Snowfall analysis over a 72-hr period from 1200 UTC 16-19 November, 2017 (NOHRSC) b) 72-hr period from 1200 UTC 19- 22 November, 2017 (NOHRSC)