

1.6 FROZEN TO THE SADDLE: A 19th CENTURY FLASH FREEZE INVESTIGATION

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1. INTRODUCTION

A blast of arctic air quickly rolled over the open fields of the Midwest in late December 1836, killing at least five people in Illinois and devastating livestock. The sharp drop in temperature became the stuff of legend, resulting in fanciful-sounding tales decades later of chickens and pigs frozen in their tracks, wagon wheels to the ground, and men to their saddles. In the retelling of their experiences, the settlers attributed names to this extreme weather event such as “Cold Tuesday” and “The Cold Day in Illinois”. In Lacon Township, Illinois, most called it “Butler’s Snap” in memory of a Mr. Butler and his daughter who were frozen to death after being caught out in the storm. However, to most pioneers, it was referred to simply as the “Sudden Change”.

The “Sudden Change”, notably described in Ludlum (1968), is reexamined here using newly digitized and quality controlled weather data obtained through the Climate Database Modernization Program (CDMP) to reconstruct the movement of the coldwave across the central and eastern US from 19-21 December 1836.

2. BACKGROUND

Meteorologist and historian, David M. Ludlum, described this event in *Early American Winters II, 1821-1870*, referencing many personal accounts of the event from newspapers, personal diaries, and other publications. Although the most dramatic reports of this storm were from Illinois, accounts of the rapid change from mild weather on 19 December 1836 to plummeting temperatures on the 20 December 1836 were from as far north as Fort Snelling,

near Minneapolis, MN, south to New Orleans, LA. One such account from Ludlum (1968) was recorded by John Moses as the cold arctic air rolled through Illinois on 20 December 1836:

“About two o’clock in the afternoon it began to grow dark, from a heavy, black cloud which was seen in the northwest. Almost instantly the strong wind ... swept over the land, and everything was frozen hard. The water in the little ponds in the roads froze in waves, sharp edged and pointed as the gale had blown it ... Two young men were frozen to death near Rushville [IL]. One of them was found with his back against a tree, with his horse’s bridle over his arm and his horse frozen in front of him. The other was partly in a kneeling position, with a tinder box in one hand and a flint in the other, with both eyes wide open as if intent on trying to strike a light. Many casualties were reported ... but the ice was frozen in the stream, as variously reported, from six inches to a foot in thickness in a few hours.”

These fascinating and disturbing tales of a flash freeze continue throughout Ludlum’s chapter. While the Sudden Change was dramatic for pioneers of the time, this was not the only storm of this caliber studied that produced similar conditions of a flash freeze. Wendland (1987) presented a study of the frequency and intensity of early winter coldwaves, specifically November coldwaves, over the north central United States from 1901 through the mid 1980’s. In total, 22 events satisfied the criteria of having a >22°C (39.6°F) difference between the maximum temperatures and between minimum temperatures the following day, and when the minimum temperature fell to freezing or below. (Note: As Ludlum (1968) and CDMP-Forts

temperature are in degrees Fahrenheit and snow in inches, those conventions are used hereafter.)

The first destructive coldwave reported by Wendland (1987) to impact the central U.S. occurred on 13 November 1909. Along with record snowfall over the region, damaging winds were observed over the Great Lakes and temperature falls $>40^{\circ}\text{F}$ were felt across Missouri. The second and most severe coldwave of those studied, occurred only two years later on 10-11 November 1911 and produced large gales that pushed vessels ashore in the Great Lakes, as had happened during the Sudden Change of 1836. In addition, morning temperatures on 10 November 2011 fell by $20\text{--}36^{\circ}\text{F}$ across the Dakotas, Nebraska and western Minnesota (Bowie 1911). Once the storm system reached Illinois, Indiana, Wisconsin, and Missouri on 11 November 1911, temperatures were reported to have fallen by more than 60°F (Wendland 1987).

Another storm similar to the Sudden Change, in terms of impacts, was that of the Armistice Day storm of 1940. Dozens of hunters were drawn to the Mississippi River on 11 November 1940, due to the favorable weather that had started the day. By that afternoon, temperatures were falling rapidly with increasing northwest winds, and by the next day, 1-2 feet of snow had fallen across Minnesota and Iowa (Knarr 1941). Nearly a dozen hunters were marooned on an island that night and another dozen drowned when their boat overturned (Wendland 1987). In addition to the large amount of snow, strong damaging winds were reported, which sunk vessels on the Upper Great Lakes (Knarr 1941). Chicago IL experienced an afternoon high temperature of 63°F but fell to 20°F by midnight. Generally, 24-hour temperature drops of 40°F were observed across Kansas, Iowa, Illinois, and Missouri (Wendland 1987). While the exact number of deaths from the Sudden Change is unknown, a staggering total of 157 people lost their lives as a direct or indirect result of the Armistice Day storm. Additionally, hundreds of thousands of

livestock were lost and millions of dollars in property damage occurred.

3. DATA AVAILABILITY

In addition to personal accounts of the Sudden Change, Ludlum (1968) used meteorological data drawn from private observers and military forts to reconstruct the movement of this cold outbreak across the country during 20-21 December 1836.

Newly digitized and quality-controlled surface observation data processed through the CDMP 19th Century Forts and Voluntary Observers Database Build Project are used to produce a more thorough examination of the Sudden Change (Table 1). In addition to data locations mentioned in Ludlum (1968), the CDMP dataset includes 17 more stations that enable finer-grained tracking of the movement of the cold front from west to east.

The CDMP Forts project (Dupigny-Giroux 2007) began in the early 2000's, with the goal of digitizing and providing access to meteorological data taken by military and volunteer observers across the United States during the 18th and 19th centuries. Detailed metadata documenting the observer, site location, information about the instruments, and other pertinent information is recorded by trained climatologists during the keying process. To date, 451 stations have been digitized across the continental U.S. and Alaska. Once a station is digitized, a suite of quality-control tests is performed on the data to ensure that the observations are keyed correctly and logically-consistent (Westcott et al. 2011). Currently, 299 stations have been quality-controlled and are available for use. Access to digital data at additional locations during the 1800's allows for more in-depth study of extreme events in the historical record.

During December 1836, 31 of the 451 digitized stations had active weather observers. A search of the CDMP image records located another 7 undigitized stations with data during the event, so 38 locations across the eastern half of the

United States had viable data for tracking the path of this event. A map of the stations can be seen in Figure 1. Twelve of the Army forts, most notably those in present-day Florida, and the northern and western Plains states, were located in territories that were not yet official states.

Table 1. A Comparison between the stations used by Ludlum (1968) and those in the CDMP database. Stations used in both studies are noted. The CDMP database had a total of 38 CDMP stations, whereas Ludlum used 21 locations.

Ludlum	CDMP Forts
Augusta, IL (P)	St. Augustine, FL
Belleville, IL (P)	Fort Jessop, LA
Fort Armstrong, IL	Fort Independence, MA
Burlington, IA (N)	Williamstown, MA
Springfield, IL (N)	Baltimore, MD
Natchez, MS (P)	Fort McHenry, MD
Monroe, LA (P)	Houlton, ME
Panther Creek Twnshp, IL (P)	Fort Brady, MI
Cincinnati, OH (P/N)	St. Louis Arsenal, MO
Detroit, MI (N)	Fort Constitution, NH
SE (Marietta), OH (P)	Hanover, NH
Used in both studies	Brooklyn Heights, NY
	Flatbush, NY
	Fort Columbus, NY
	Watervliet Arsenal, NY
	West Point, NY
	Steubenville, OH
	Fort Gibson, OK
	Fort Towson, OK
	Providence, RI
	Fort Monroe, VA
	Kanawha Salines, WV
	Fort Mitchell, AL
	Dearbornville Arsenal, MI
	Watertown Arsenal, MA
	Picolata, FL
	Fort Wood, NY
	Allegheny Arsenal, PA

(P) = Private Observer; (N) = Newspaper

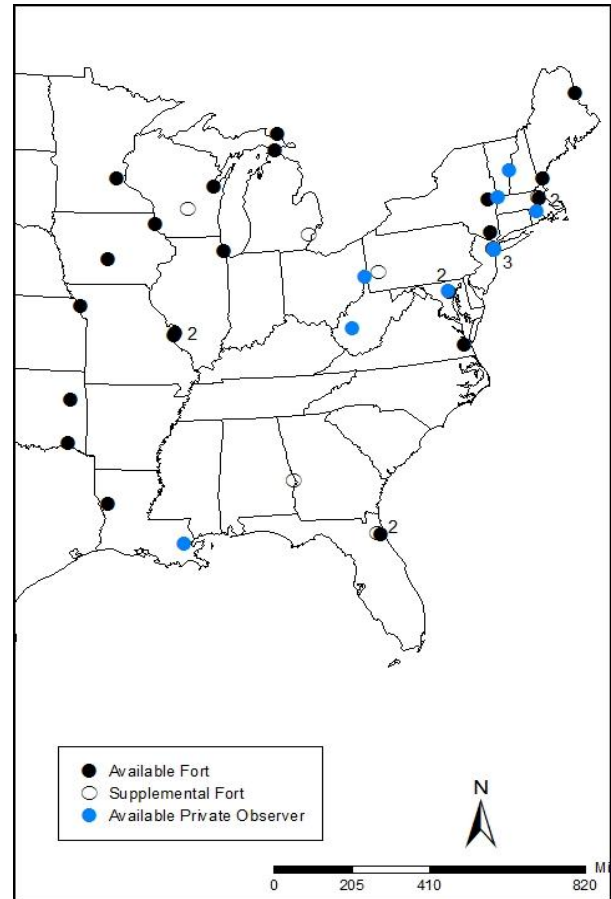


Figure 1. All CDMP stations used in analysis. Black circles indicate stations at a US Army Fort. Blue circles indicate volunteer observer stations. Hollow circles indicate supplemental stations from the CDMP image library, keyed specifically for this study.

Over three-quarters (29) of the stations were located at military outposts and were part of a network begun by the United States Army Surgeon General. The observations were typically recorded by the camp surgeon. Standardized forms (Figure 2) were used at these locations. These forms had columns to record temperature (0700, 1400, 2100 local time (LT), and the daily mean), wind direction (0700 and 1400 LT), precipitation (daily amount), and the state of the weather (0700 and 1400 LT). There was also a column where the observer could write remarks about the weather of the day. While not all the observers wrote detailed remarks for each day, this added information

was invaluable in determining the location and severity of this event.

Voluntary observers recorded the observations at the remaining 9 stations. Unlike the Army's observations, these observations were not recorded in a standardized format. In some cases, such as New Orleans, LA, the observer took measurements at various non-standardized times during the day. Also, the variables measured differ greatly from station to station. For instance, the observer in Steubenville, OH recorded barometric pressure three times a day, in addition to the suite of variables included on the military forms. Other observers recorded considerably less data. For example, at Brooklyn Heights NY, the observer only recorded maximum and minimum temperature. Nevertheless, data from all stations were used here to describe the event.

DIARY—Continued.

DATE	WIND	WEATHER	RAIN	REMARKS							
1st	22	18	14.5	17.5	14.5	17.5	14.5	17.5			
2d	14	22	23	23.5	23.5	23.5	23.5	23.5			
3d	18	22	23	23.5	23.5	23.5	23.5	23.5			
4th	22	23	23	23.5	23.5	23.5	23.5	23.5			
5th	22	23	23	23.5	23.5	23.5	23.5	23.5			
6th	11	21	23	23.5	23.5	23.5	23.5	23.5			
7th	24	26	24	23.5	23.5	23.5	23.5	23.5			
8th	24	26	24	23.5	23.5	23.5	23.5	23.5			
9th	22	23	23	23.5	23.5	23.5	23.5	23.5			
10th	21	21	21	21.5	21.5	21.5	21.5	21.5			
11th	24	25	21	21.5	21.5	21.5	21.5	21.5			
12th	22	22	22	22.5	22.5	22.5	22.5	22.5			
13th	20	22	22	22.5	22.5	22.5	22.5	22.5			
14th	24	26	24	23.5	23.5	23.5	23.5	23.5			
15th	22	24	18	19.5	19.5	19.5	19.5	19.5			
16th	20	20	20	20.5	20.5	20.5	20.5	20.5			
17th	15	15	10	11.5	11.5	11.5	11.5	11.5			
18th	15	16	17	15.5	15.5	15.5	15.5	15.5			
19th	24	24	20	20.5	20.5	20.5	20.5	20.5			
20th	24	1	2	2.5	2.5	2.5	2.5	2.5			
21st	19	19	19	19.5	19.5	19.5	19.5	19.5			
22d	22	22	22	22.5	22.5	22.5	22.5	22.5			
23d	22	26	13	13.5	13.5	13.5	13.5	13.5			
24th	20	25	22	22.5	22.5	22.5	22.5	22.5			
25th	22	2	10	10.5	10.5	10.5	10.5	10.5			
26th	19	10	12	12.5	12.5	12.5	12.5	12.5			
27th	15	18	16	16.5	16.5	16.5	16.5	16.5			
28th	22	24	23	23.5	23.5	23.5	23.5	23.5			
29th	20	25	26	26.5	26.5	26.5	26.5	26.5			
30th	25	25	16	16.5	16.5	16.5	16.5	16.5			
31st	27	28	31	31.5	31.5	31.5	31.5	31.5			
Mean	22.4	23.0	23.3	23.3	23.3	23.3	23.3	23.3			

79.896

Figure 2. December 1836 U.S. Army Surgeon observer form from Fort Des Moines, IA, which is near modern day Des Moines, IA.

4. SYNOPTIC OVERVIEW

The following sections provide a detailed account of the event by using the quality-controlled data provided by the CDMP Forts project.

18 December 1836

On the afternoon of 18 December 1836, temperatures were between 15°F and 25°F across the Upper Midwest and Great Lakes, with mostly 30°F readings found across New England and 40-50°F readings along the Gulf Coast. While wind information is somewhat lacking across the Deep South, a southerly return flow of warm air is indicated from southern Oklahoma northward to Minnesota and Wisconsin. These southerly winds, along with the westerly winds from Michigan eastward to the New England states, and rising pressure in the northeastern United States, indicate that an area of high pressure was building into the Appalachians and New England. This is further supported by observer comments from Watertown Arsenal, MA and Baltimore, MD, which indicated it was windy and cold along the Atlantic coast. Cloud conditions were generally “fair”; however, cloudy conditions were reported over eastern Missouri and Northern Michigan. In addition, snow was reported in the St. Louis region.

Observers of this era did not typically record wind or cloud cover information after dark, which limits the discussion of synoptic conditions during the evening of 18 December. A few basic points can still be made, however. Increasing barometric pressures in New England and northwesterly winds indicate that high pressure was continuing to build into the area. The temperature distribution shows mostly 20-30°F readings across New England, 15-30°F values from Wisconsin south to Missouri, a pocket of ≤10°F readings across the southern Great Lakes region, and >35°F readings in the deep South. It is inferred based on the afternoon wind field and the evening temperature distribution, that high pressure was situated near the Ohio

Valley/Southern Great Lakes Region. This high pressure likely led to the calm winds, clear skies, and low dew points that would favor the low temperatures in this area.

19 December 1836

Weather conditions by the morning of 19 December 1836 continued to reflect a ridge of high pressure over the eastern Ohio Valley or Appalachian Region. Southerly winds and cloudy conditions were reported from Louisiana to Michigan, ahead of the developing frontal system to the west. Farther east, winds were generally westerly, although there was a mix of northwesterly and southwesterly reports. Cloud conditions over New England were mostly clear to fair. Temperatures varied considerably along the East Coast, with values between 0°F and 10°F from Houlton, ME through Watervliet Arsenal, NY and southwestward into Ohio. Under the cloud cover to the west, temperatures were warmer, generally 15-30°F in the northern plains, with 30-50°F from Missouri south to Louisiana. One cold spot of note is Fort Mitchell, AL, at 23°F, with a north wind. However, northeastern Florida was a great deal warmer, near 53°F, also under a north wind. It is possible that local effects, such as land breezes, may have contributed to this seeming discrepancy. During the morning, snow or a rain-snow mix was reported from Oklahoma to the Upper Peninsula of Michigan.

By the afternoon, under cloudy skies and sustained southerly winds, temperatures climbed much higher over the Midwest than on the 18 December. The lowest afternoon temperature was 23°F at Fort Mackinac, MI, with readings from 25-30°F across Minnesota, Wisconsin, and Michigan. Temperatures above the freezing point were found as far north as Des Moines, IA and Steubenville, OH. Temperatures across the deep South ranged from 55-63°F, with intervals of rain reported at Picolata, FL. Finally, temperatures across much of New England hovered near 30°F.

During the evening hours, temperatures remained fairly elevated throughout most of the Midwest, with temperatures as high as 32°F at Dearbornville Arsenal, MI and 40°F at Des Moines, IA. In general, temperatures ranged from 16-20°F across Upstate New York to northern Maine, 20-30°F from Minnesota through New England, 34-40°F from Iowa to Virginia, and 50-59°F across the Gulf Coast. In addition, barometric pressures across New England were at a maximum during this period, with a few locations reporting northwesterly winds, indicating that the high pressure area was centered over these states.

20 December 1836

By the morning of 20 December 1836, the arctic front entered the study's observational domain (Figure 3). Temperatures dropped sharply at Fort Snelling, MN compared to the previous evening observation, with a -2°F reading under northwest winds. Winds at Prairie Du Chien, WI had switched to northwesterly as well, but the temperature was still 34°F, similar to the prefrontal values at other stations in the area. Although the wind direction was reported as northeasterly at Des Moines, IA, it is possible that the front has moved through this station as well, particularly given the -3°F and snow reported at Fort Leavenworth, KS. In addition, there was a northwest wind at Fort Towson, OK, with a small temperature drop from the previous evening to 45°F, and a 10°F temperature drop to 26°F at Fort Gibson, OK, with snow falling during the day and a north wind. St. Louis Arsenal, MO reported rain until 1100 LT, then changed precipitation types to a mix of snow and sleet. On the warm side of the frontal zone, considerable warm advection has occurred over the last 10 hours or so, with temperatures at or above 32°F across all of Michigan, and the 40°F isotherm along a line from central Oklahoma to the Ohio River and eastward to central Virginia. Fort Jessup, LA, reported 64°F, about the same temperature as northeastern Florida.

Meanwhile, winds over the New England states were out of the south or southwest, with generally fair to clear conditions. Temperatures were generally in the 15-25°F range, with the exception of the -1°F reading at Houlton, ME.

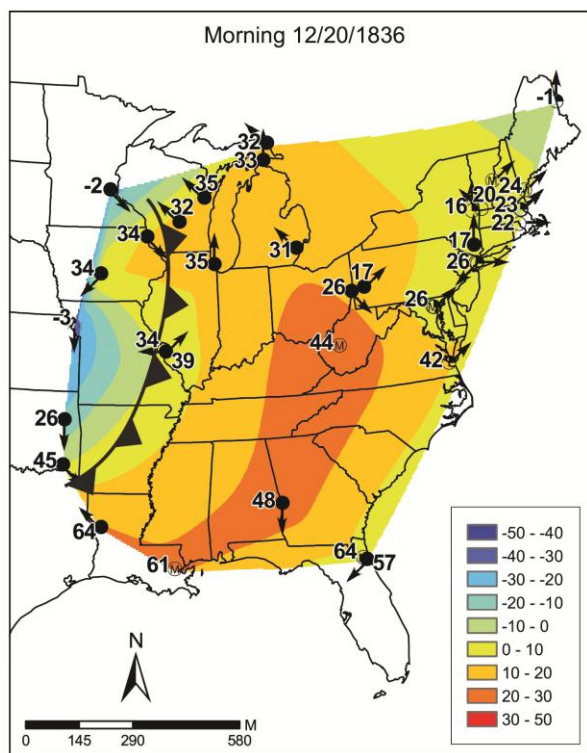


Figure 3. Morning weather map from 20 December 1836 with the most likely position of the cold front plotted. The station model at each site shows current air temperature (°F), cloud cover (fourths), wind direction, and when available, pressure in italics. Shading indicates the 24-hr temperature change (°F) from the previous morning.

By 1400 LT, the cold front ran approximately from central Wisconsin through central Illinois to central Louisiana (Figure 4). On the west side of the front, winds were out of the north or northwest. Temperatures had fallen more than 25°F at several stations since the morning observation, with Prairie Du Chien, WI at 1°F, Des Moines, IA at 0°F with snow, and St. Louis, MO at 14°F, with high winds. As far south as Oklahoma, temperatures were ≤ 20°F. Ahead of the front, over eastern Wisconsin and Michigan,

temperatures were between 34°F and 39°F, under cloudy skies. Temperatures over New England ranged from 35-45°F, with only a few exceptions. Winds were generally

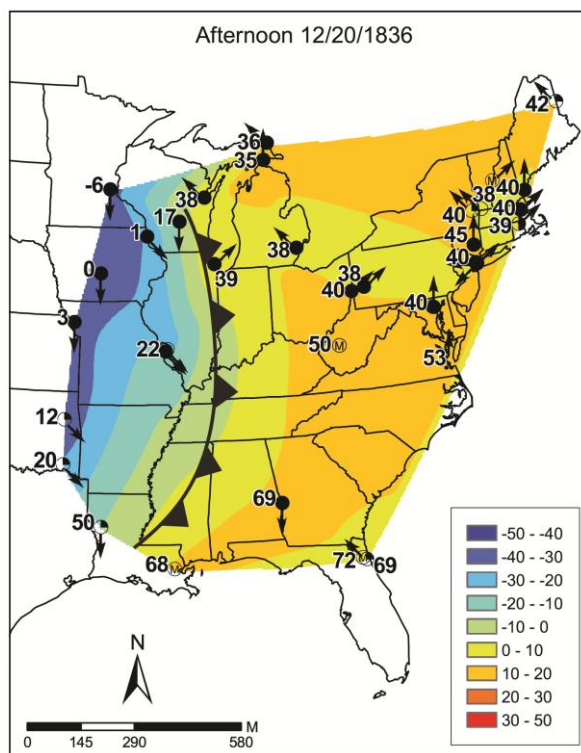


Figure 4. As in Figure 3, for the afternoon of 20 December 1836.

southerly over the entire country east of the cold front. Sky conditions were cloudy everywhere, with the exception of Oklahoma, Louisiana, northeast Florida, and a few stations in New England.

The arctic cold front did not appear to move a great deal from its 1400 LT position by late evening (Figure 5). The 2100 LT temperatures show a large zonal gradient across the upper Midwest, with a 38°F reading at Green Bay, WI and -4°F at Prairie Du Chien, WI. Bitterly cold temperatures, below 0°F, prevailed across Minnesota and Iowa. Even as far south as Fort Jessup, LA, temperatures had dropped to near the freezing mark, at 34°F. However, temperatures in Michigan remained from 38-

42°F. Temperatures along the East Coast ranged from 20°F at Houlton, ME to 70°F at Picolata FL. One interesting cold spot was Allegheny Arsenal, PA, at 21°F, which was 10-20°F colder than surrounding stations. An interpolation from the pressure field indicates that the front passed Steubenville, OH sometime around midnight on 21 December 1836. Although precipitation and cloud cover was not available at most New England stations, Providence, RI reported rain and 40°F at 2200 LT.

morning or noon on 21 December. Ahead of the front, at several of the New England sites, rain was reported, with temperatures ranging from 46-50°F and southerly or southeasterly winds. In Florida, temperatures were near 60°F with southeasterly winds.

In the morning behind the front, snow was falling at Allegheny Arsenal, PA. Temperatures across the upper Midwest were frigid, with near 20°F temperatures in western Pennsylvania, 4°F and 8°F at Fort Mackinac, MI and Fort Brady, MI,

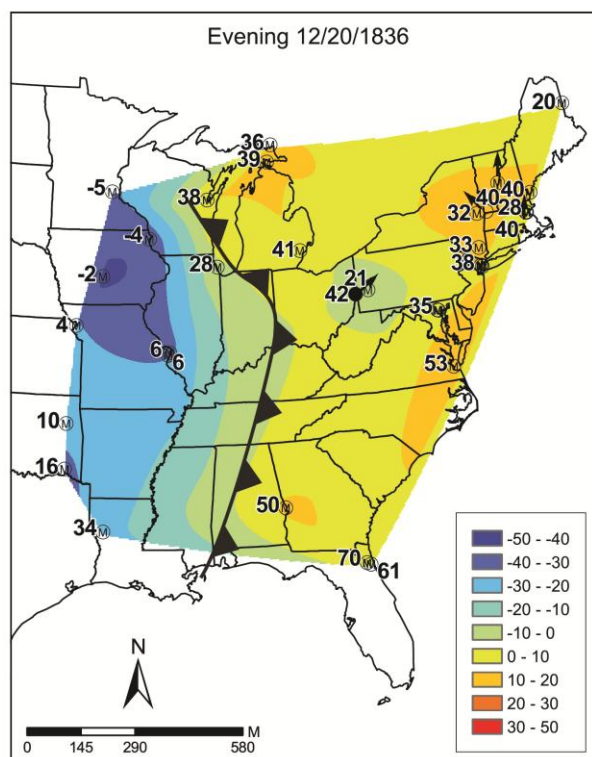


Figure 5. As in Figure 3 but for the evening of 20 December 1836.

21 December 1836

By the morning of 21 December 1836, the front had made considerable progress across the United States (Figure 6). Winds were out of the west or northwest as far east as Fort Monroe, VA and Fort McHenry, MD. This agrees with the interpolation of the barometric pressure field, which shows that the frontal pressure trough passed the East Coast stations around late

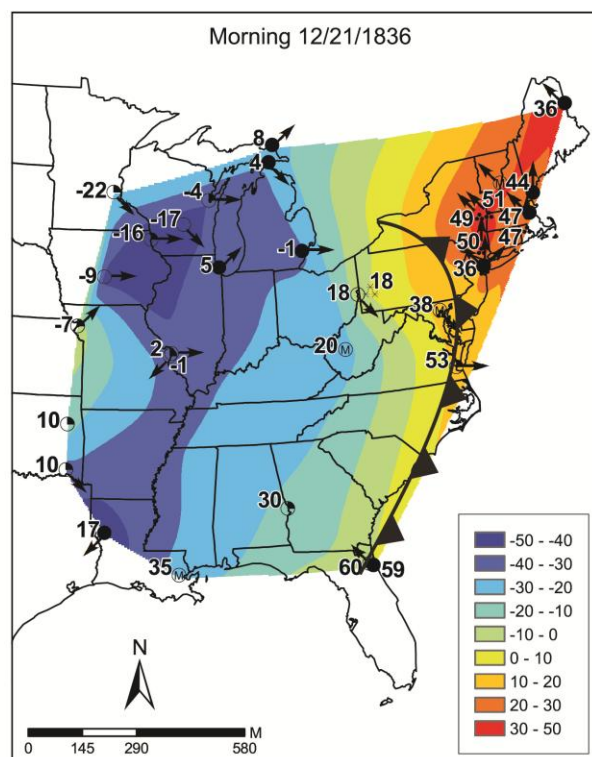


Figure 6. As in Figure 3 but for the morning of 21 December 1836.

respectively, and temperatures below -10°F in Iowa, Minnesota, and Wisconsin. In fact, the temperature at Fort Snelling, MN was an unseasonably cold -22°F at 0700 LT. Sky conditions were fair to clear across most of the country, with the exception of Michigan (presumably due to lake-effect cloud cover), Fort Jessup, LA, and Picolata, FL. The winds were generally westerly, with the exception of a

northeasterly wind at both Fort Jessup, LA and Jefferson Barracks, MO.

By the afternoon, the front had moved farther east, past West Point, NY and Williamstown, MA (Figure 8). Snow was falling at Watervliet Arsenal, NY and Williamstown, MA, with temperatures from 23-28°F. Ahead of the front, Providence, RI and Hanover, NH reported cloudy skies and southerly winds, with rain and a temperature of 50°F at Providence. Temperatures had climbed to 41°F as far north as Houlton, ME, with rain. The observer at Providence, RI left a detailed account of the event, indicating that the front had passed there in the late afternoon, with a wind shift to southwesterly by 1400 LT and northwesterly by 1600 LT.

Across Iowa, Wisconsin, and Minnesota, temperatures were below 0°F in the afternoon, with Fort Winnebago, WI reporting a -11°F. Temperatures ranged from 4-10°F in Michigan, due to considerable warming from the Great Lakes. Afternoon temperatures broke the freezing point only along the eastern seaboard and Gulf Coast. Winds across the country were generally westerly north of the Ohio Valley, and of varied direction or calm to the south.

By evening, all of the available New England stations were reporting winds out of the northwest (Figure 9). Temperatures were generally less than 10°F along and north of a line from Kansas City, MO to St Louis, MO, to Pittsburgh, PA. The observer at Dearbornville Arsenal, MI even noted that the temperature registered below 0°F for the first time that winter, and the Fort Brady, MI observer noted that the Saint Mary's River had frozen over during the night. The warm spots in New England were 40°F at Fort Independence, MA and 35°F at Houlton, ME. Farther south, Fort Monroe, VA stands out as well, with a 52°F reading, which was warmer than the temperature in northeastern Florida at this time.

5. RESULTS

This powerful cold front caused death and damage across much of the United States in 1836. Several atmospheric and societal factors came together to make this event even more damaging. During the day of 19 December 1836, a substantial warm-up occurred in the western parts of the study area before the frontal passage. From Iowa south to Louisiana, morning temperatures were over 30°F warmer than the previous morning. Des Moines, IA and St. Louis, MO had temperatures of 40°F by 2100 LT on 19 December 1836.

Temperatures remained above freezing into the morning of 20 December 1836 for most of the study area (Figure 3), except for the extreme western portion where temperatures were already plunging to below zero. When these warmer temperatures were combined with the power of the front, temperatures dropped sharply in Iowa, western Wisconsin and Illinois during the day of 20 December 1836. Throughout this area, changes of over 20°F between the 0700 LT and 1400 LT observations on the 20 December 1836 were fairly commonplace (Figure 4). Des Moines, IA dropped from 34°F at 0700 LT to 0°F by 1400 LT, a rate of decrease of 4.9°F hr⁻¹. Even as far south as Fort Jessup, LA, temperatures fell by 14 degrees by 1400 LT.

This 1836 flash freeze event is similar to the 11 November 1911 storm that brought rapid temperature drops across a large region. A maximum temperature decrease was recorded in Kansas City, MO of 13°F in only 20 minutes with a total decline of 54.5°F in just 4.3 hours, and Sedalia, MO temperatures fell 40°F in 4 hours. Also, Chicago, IL fell from 74°F to 13°F by the following morning (Wendland 1987).

The rapidly dropping temperatures continued into the morning of 21 December 1836 (Figures 5 and 6) where most of Iowa, Wisconsin and Minnesota experienced temperatures well below 0°F. Twenty-four hour temperature changes of over 40°F occurred over parts of Iowa,

Wisconsin, and Illinois. The most extreme temperature observed was -16°F on the morning of 21 December 1836 in Prairie Du Chien, WI, which was 50°F lower than that recorded the previous morning (Figure 6). This is similar in magnitude to the temperature drops experienced with the Armistice Day storm of 1940. Morning temperatures were very warm. However, by the afternoon, the front had passed Minnesota, Iowa and much of Illinois, dropping temperatures well below freezing in just a matter of hours along with rain changing over to snow.

Figure 7 depicts the area that was plunged into the cold air on 20 December 1836. The two black lines on this figure show the zero 24 hour temperature change lines for 0700 LT and 2100 LT from 19 to 20 December 1836. These lines do not indicate the location of the front at these time periods due to the lag time between frontal passage and the advection of cold air. While the area between the 0700 LT and 2100 LT lines experienced a temperature decrease during the course of the daytime hours, the dark red line shows where the temperature was at freezing (32°F) by 1400 LT. It was postulated that the area between the 0700 LT and 1400 LT line should have experienced the most cold weather impacts. To examine this, the impacts documented by Ludlum (1968) were plotted on the map as well. All impact reports are in western Illinois, between the 0700 LT and 1400 LT lines. This area started with morning temperatures higher than the 0700 LT temperatures on the 19 December 1836 (not shown), but by 1400 LT on 20 December 1836, temperatures fell quickly to below freezing during the time of the day when diurnal warming is expected.

After pushing through the Midwest, the front continued moving quickly across the eastern half of the United States. By the afternoon of 21 December 1836, the cold front had passed through New York and had reached the eastern coastline while the largest temperature changes had moved eastward from Iowa and Illinois to West Virginia and southeastern Ohio (Figure 8). By the morning of 22 December 1836 (Figures 9

and 10), the front had pushed well off the eastern United States. The 24-hr temperature changes were just as dramatic along the East Coast as they were in Iowa and Illinois. They ranged from a 31°F drop in Saint Augustine, FL, to a 44.5°F decrease at Williamstown, MA. Ludlum (1968) did not report any cold impacts in the eastern U.S., but the temperatures, while having similar magnitude drops to those in the Midwest, did not go below 0°F in the northeast before temperatures began to rise again with the approach of the next system.

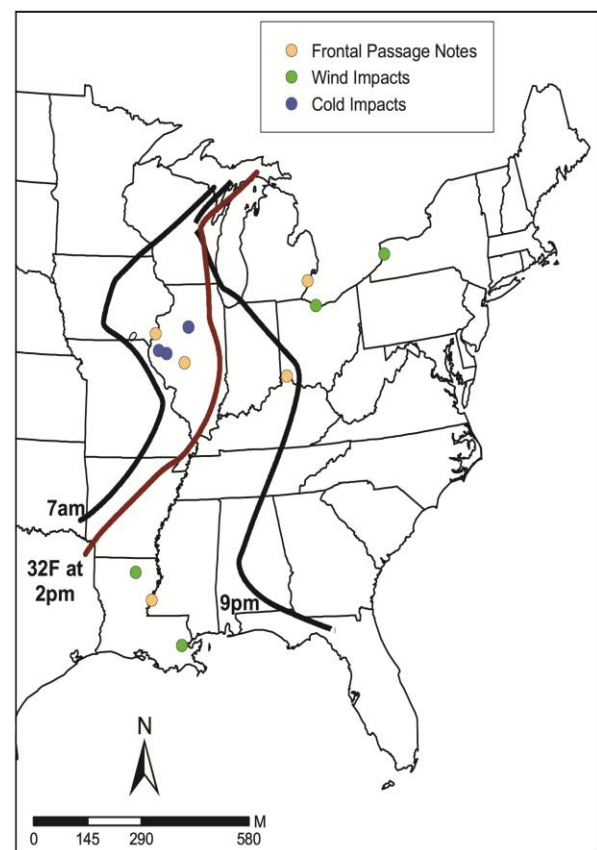


Figure 7. Impacts of the Sudden Freeze on 20 December 1836. The two bold black lines indicate the 24-hour zero change lines at 0700 LT and 1400 LT from 19-20 December 1836. The bold dark red line indicates the 1400 LT 32°F isotherm on 20 December 1836. Impacts adapted from Ludlum (1968).

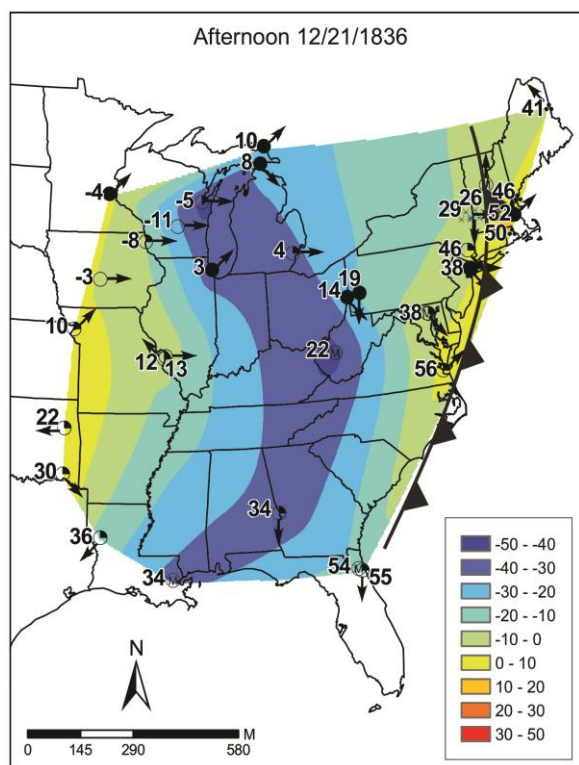


Figure 8. As in Figure 3 but for the afternoon of 21 December 1836.

6. CONCLUSIONS

Meteorologist David Ludlum first wrote of the Sudden Change of 1836 and the tales that resulted from this arctic air outbreak across the Midwest. He used the data available to him at the time to reconstruct the event. Use of newly digitized and quality-controlled data from the CDMP 19th Century Forts and Voluntary Observers Database Build Project along with newer mapping technologies (e.g. ArcGIS tools) allows for a more detailed analysis of this event.

After a day of thawing and unseasonably warm temperatures for late December, the early American settlers were unprepared for the sudden change in weather conditions. Intense cold air moved over the open prairie during 20 December 1836 plunging the mercury from above freezing to below 0°F in just a matter of hours. The cold front quickly moved to the East Coast by 21 December 1836, changing rain to

snow and creating destructive winds from across the Great Lakes to as far south as Louisiana. Years later, the same area would experience similar conditions in November 1911 and again with the Armistice Day storm of 1940, marked by rapidly dropping temperatures, increasing winds, and snow.

Even though most of the eastern half of the U.S. experienced sharp decreases in temperature, the most dramatic impacts were felt over Illinois. The afternoon timing and strength of the cold frontal passage across Illinois, in conjunction with warmer temperatures ahead of the front, left the pioneers unprepared for the flash freeze. The result of this was evident in the anecdotal tales of loss of life and livestock.

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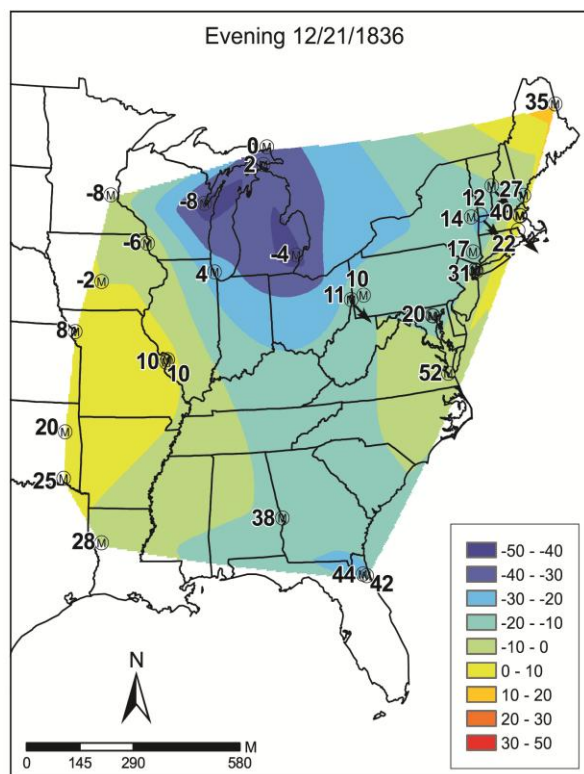


Figure 9. As in Figure 3 but for the evening of 21 December 1836.

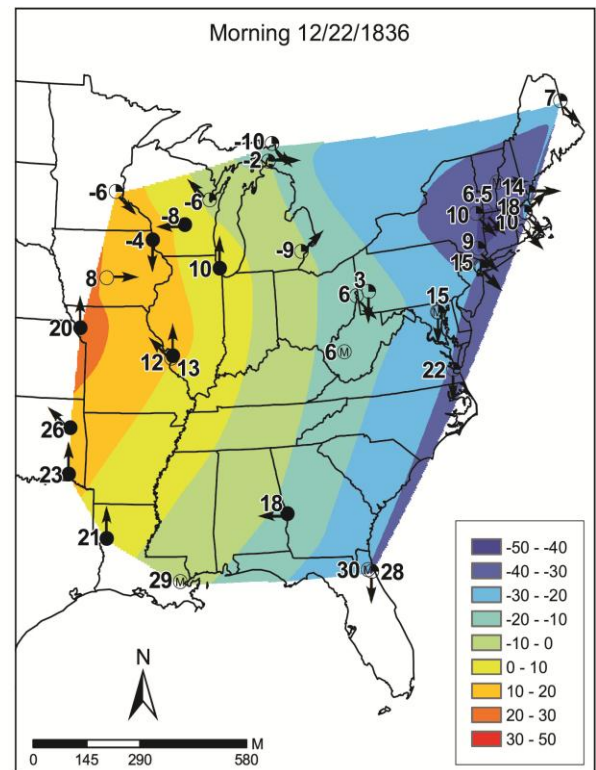


Figure 10. As in Figure 3 but for the morning of 22 December 1836.