1.3 THE FORMS TELL A TALE – UNIQUE WEATHER OBSERVING PRACTICES OF THE 19TH CENTURY

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1. BACKGROUND

Prior to the establishment of the United States Weather Bureau in the 1890's, volunteer civilian and military weather observers throughout the growing Nation observed and documented weather and climate data. Under NOAA's Climate Database Modernization Program (CDMP), which is managed through NOAA's National Climatic Data Center (NCDC), these valuable data are being keyed into a digitized format, and their metadata collected, under the CDMP "Forts" program.

As part of this process, CDMP meteorologists closely inspect digital images of the original observers' forms – every image available, from every station to be keyed; that's over 200 stations to date. This means literally tens of thousands of these historic forms have already been inspected, one by one, by professional meteorologists. Thus, these CDMP meteorologists are afforded the unique opportunity to note the observing practices of this bygone day.

2. FORTS PROJECT OVERVIEW

The CDMP Forts program is a successful example of a cooperative effort between government agencies and the private sector. CDMP meteorologists at NCDC in Asheville, NC, including contractors employed by CDMP partners Information Manufacturing Corporation and STG, Inc., work closely with the Midwestern Regional Climate Center (MRCC) in Champaign, IL, and with Kentucky-based keying and imaging contractors SourceCorp. While this document will focus primarily on the discoveries and information gleaned by CDMP meteorologists at NCDC, each group contributes vitally to the overall Forts effort.

The MRCC has inventoried and selected approximately 160 first-priority stations, all with data collected prior to 1893's start of U.S. Weather Bureau observations, for keying into digital data files. These stations include U.S. Army Signal Service locations (many of which were the immediate predecessors of the Weather Bureau stations) and volunteer observers, including Army surgeons, noted scientists, and other professionals, who often submitted observations under the auspices of the Smithsonian Institution.

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These original observers' forms, which extend as far back as the 1780's and vary widely in quality, content, and format, were originally microfilmed at NCDC in the 1950's. For ease of keying and to preserve the images (as the original film reels were eventually destroyed), these microfilm reels were converted by SourceCorp to a JPEG image format.

Once CDMP meteorologists prepare the data for keying using MRCC-developed custom web-based tools, keying professionals at SourceCorp's Annville, KY location carefully key each form, following the instructions provided by CDMP. When keying is completed for a station, its raw keyed data are then subjected to rigorous Quality Control (QC) at MRCC to meet NCDC standards, and are converted to standard digital formats. Once QC is completed on the data, they will be ingested into NCDC's digital database and made available to the research community. A few researchers are already using "raw" versions of the keyed data, which not only provides them an early look at some of the data, but also helps MRCC and CDMP by spotting any anomalies or problems in the data.

3. ELEMENTS OBSERVED

It's probably not surprising that many of the weather elements observed in the 19th century are still recorded today, and that several elements have been added since then. But it's perhaps more surprising to note that these early observers at times took much more detailed observations than those in modern times, and recorded elements no longer observed.

3.1 *Meteorological elements*

In the earliest Smithsonian Institution-sponsored volunteer observations, which began in the late 1840's, as well as on Signal Service forms from roughly the same time period, the amount of sky cloud cover present was not expressed as it is today. Rather than observing the amount of sky covered by clouds, it was observed as "Clearness of the Sky." The tradition of expressing this amount in tenths of sky coverage did begin here, but the number represented the polar opposite of what it would later be known; a "10" entered in this column represented a totally clear sky, and "0" meant completely cloudy. This practice changed over to the modern practice of observing the amount of sky covered with clouds in the late 1850's.

Signal Service forms from the mid-1880's were very detailed; each month's set of forms normally encompassed ten full pages of observations. Among these were observations of the direction of cloud movement; this was carried as an element on certain U.S. Weather Bureau forms until 1940. Another element observed by the Signal Service was vapor pressure, which was still recorded by the Weather Bureau as late as 1948.

The "Temperature in the Sun" may seem an odd observational element to modern meteorologists, but that temperature was recorded on certain forms, including frequent observations made at the Washington Naval Observatory. In addition to the standard dry bulb, wet bulb, and attached thermometers, the Naval Observatory recorded both "Sun" and "Rad" (radiation) temperatures beginning in 1842. A "Wool" temperature column was also briefly added, though inspection of these forms suggests this reading was never actually made.

An interesting set of columns on this era's Signal Service forms was entitled simply "Sunset Observations." One would be hard-pressed to find these columns on an observer's form today. Under this header were two columns: one entitled "Character of Prediction," which described the site's forecast for the general character of the next day's weather (e.g. "Fair" or "Foul"); and a second called "Verified or Not Verified," expressed as a simple "Yes" or "No," which pertained to the previous day's forecast results. The number of "Yes" entries on many of these forms seems perhaps a bit generous….

3.2 *Non-weather elements*

Not only were weather-related elements observed on these forms, many types of non-weather events and elements were described.

There were several water-related observations taken in the 1800's. For example, the 1880's Signal Service forms contained fields on which river depth and change in depth were noted, as well as "Temperature of Water, River, Lake, or Ocean." Where available, these data are being keyed as part of the CDMP Forts project.

Of great interest in the 1800's was the observation of features such as auroras, solar halos, sun dogs, phases of the moon, and the occasional comet or meteor shower. These elements are perhaps just as interesting today, but their inclusion along with weather observations is mostly a thing of the past.

4. SYSTEMATIC OBSERVATIONAL PROBLEMS

As CDMP meteorologists have viewed thousands of these 1800's weather observational forms, some systematic errors and problems with the observations have become apparent.

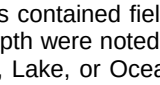
Perhaps the most prevalent of these systematic errors involves improper calculations of wet bulb temperatures. From around 1850 until well into the 1860's, there were numerous observations for which the wet bulb temperature was found to be higher than the dry bulb. This appears to be especially prevalent in dry Western U.S. Signal Service locations. In other cases, while the wet bulb temperature may not have been actually lower, it is clear that the amount of wet bulb depression is far too low given the arid nature and otherwise dry weather at the time for these Western stations. Unlike the simple case of a wet bulb higher than dry bulb, this "insufficiently depressed" wet bulb can be difficult to identify reliably through QC, so it would be advisable to put in station-specific range tests for these Western stations.

Apparently, Signal Service headquarters became aware of the problem fairly early on in this period, as at least one station (Albuquerque, NM) noted in March 1850 that the observation of wet bulb temperatures was discontinued as per a circular received by their office.

Similarly, observers in chillier climes struggled with the difficulties in taking wet bulb readings when the dry bulb temperature was below freezing. This was noted by the observers themselves at several cold weather sites.

A less widespread but nonetheless noteworthy observational quirk was the mixing of precipitation units. Several stations, including, notably, Fort Davis, TX and Fort Apache, AZ, observed daily precipitation in cubic centimeters, but converted the monthly total to inches. This was noted over periods of several years at these stations.

Another prevailing issue is the manner in which some observers denoted negative numbers, such as temperatures below zero. On numerous forms, this was expressed as a zero, with a line under it, and then a number; e.g.:



This temperature would be negative-ten (i.e., ten below zero).

Other stations simply underlined the negative value itself. At least one station (Franklin, PA) recorded a negative as a mathematic expression; e.g., negative-10 would be recorded "0-10".

Finally, a technique that seems rather clever has backfired due to the now outdated original preservation of the images. Most of these 1800's-era forms were originally microfilmed in the 1950's, and the original paper forms destroyed. Not surprisingly, these microfilm images are in black and white.

At least one observer, at Fort Totten, ND, added a footnote to his forms over a period of several winters that negative temperatures were recorded in red. Obviously, in North Dakota, this resulted in a lot of red temperatures. Unfortunately, this information is now lost, as this was the only way he identified the negative numbers, and it is impossible to differentiate between the red and black numbers on these images.

The problem with colors on the forms being lost is not limited to these negative temperatures. Occasional forms at numerous stations have notations which indicate that changes, such as corrected observations, are noted in red. Fortunately, CDMP now has the option to digitally image any surviving paper forms in color to preserve these sorts of notations.

5. UNIQUE METADATA ELEMENTS

One of the tasks CDMP meteorologists perform when reviewing these "Forts" images is to key any metadata elements they may find entered on the form. Instrumentation, station location clues, observer information, and any other potentially useful metadata may be extracted. These metadata have been invaluable in piecing together both larger trends in the observing practices of the day, but also unique elements associated with individual observers and stations, elements which can significantly effect the usage of that station's data, and which otherwise might have gone undetected or unknown.

The following is a sampling of some of the unique metadata uncovered by CDMP meteorologists in the examination of these forms. Some of these may be considered scientifically noteworthy, and others as simply entertaining curiosities:

- It's fairly well known that many of the first U.S. Weather Bureau offices began as Army Signal Service observing stations. But the observer signatures on the forms themselves reveal that the same observers also stayed on in their former positions; the titles they listed after their names simply changed from, "Sergeant., U.S. Army Signal Corps" to "Observer, U.S. Weather Bureau."

- Many of the U.S. Army forts made two sets of often simultaneous observations, one set by Army surgeons and other hospital staff, and one by "regular Army" personnel.

- In 1833, the observer at Burlington, VT moved to Hatley in what he termed "Lower Canada" where he continued sporadic observations, then returned to Burlington and continued observations there in 1837. Similarly, volunteer observer John Fleming of Readington, NJ apparently took his show on the road. Between 1866 and 1878, Mr. Fleming dutifully made weather observations at no fewer than nine different New Jersey towns, all within 20 miles or so of Readington, before finally settling down at home.

- Several observers reported more than the weather. Weekly and monthly death tolls were reported by observers in several Eastern cities; an observer in Buffalo, NY actually added a "Deaths" column to his regular weather observation form alongside more mundane elements as temperature and barometer. The Key West, FL observer made regular observations of, and even predictions of, deaths due to yellow fever. This is all perhaps less surprising when one realizes that many of the volunteer observers were physicians.

- The Oakland Institute in Jackson, MS was ahead of its time. This school for girls commissioned their female students – or as the forms themselves read, "the young ladies of the First Class," – to take observations from 1849 to 1855; these were apparently the first weather observations ever made in Jackson.

- Young girls had no monopoly on weather observing. A Mr. Angelo N. F. Goodell of Nyack, NY commenced weather observations on June 1, 1858; according to the diary in which he made these almost hourly daytime temperature obs, Mr. Goodell was "aged 15 years, 8 months, and 3 days" at the time. Mr. Goodell continued observations well into his adulthood.

- Observer Jacob T. Stern of Logan, IA made use of what he had. In early 1868, he reported to the Smithsonian Institution that "...I measure the rain at present in an old fruit can." He received an official rain gauge from the Smithsonian within the year.

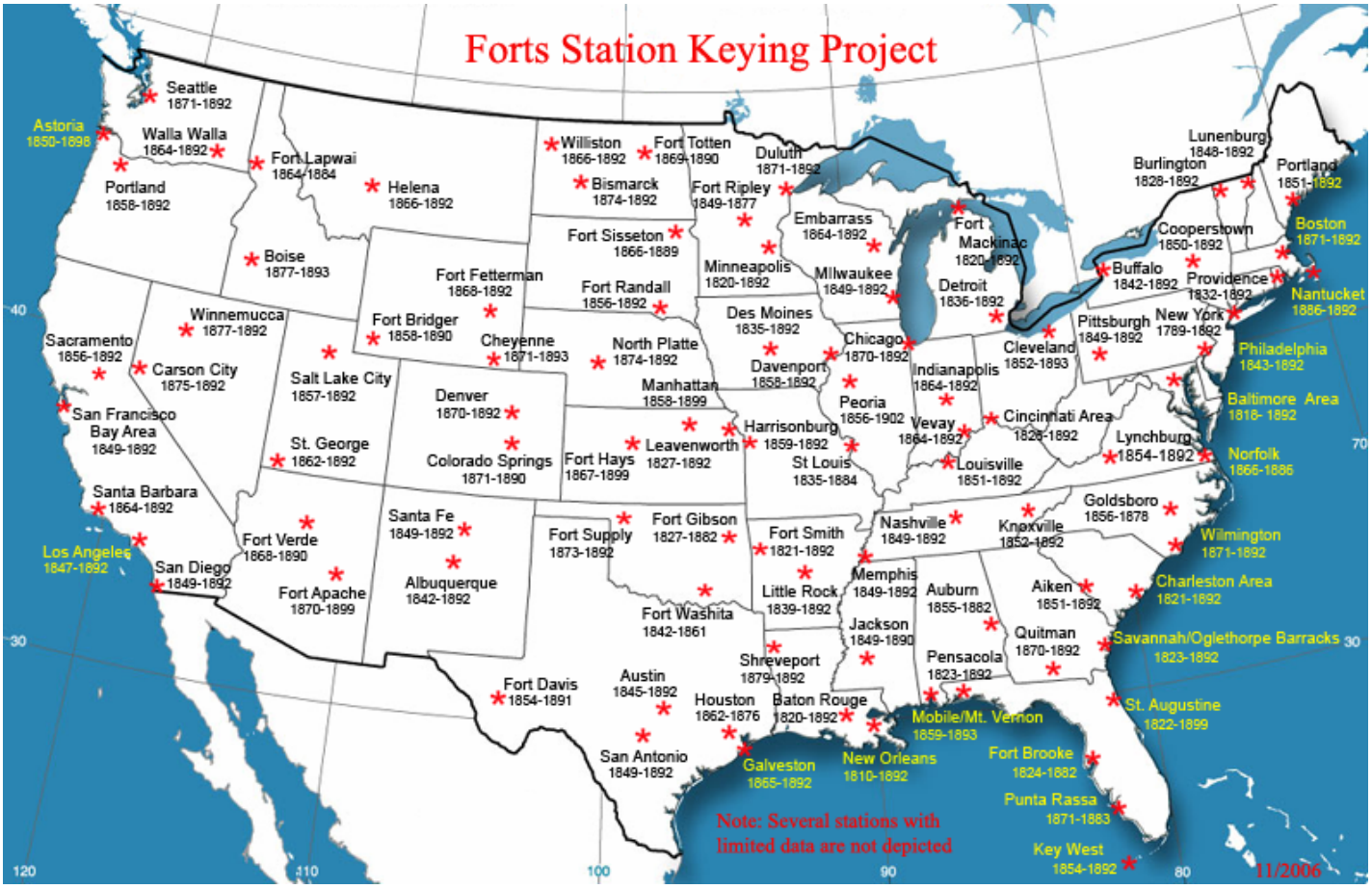
- One observer near New York City made almost daily reports of earthquakes. Apparently the Northeast was a little more geologically active in the mid-1800's than today! Similarly, observers in several very inland locations reported "hurricanes" striking their towns; apparently the meaning of "hurricane" has become more specific over the years, as the 18th-century observers seemed to be referring merely to very strong winds.

- Some of the earliest observations found are from what is now Lower Manhattan in New York City; in the Forts project, these begin in the late 1780's. Mixed in with remarks about gales and cold waves, the anonymous observer there notes such events as special votes held to establish where Congress would meet, the ratification of treaties between the fledgling United States and such diverse parties as England and the Creek Nation, and this note, from August 30, 1790: "The President of the United States with his family went from this place to Mount Vernon in Va."

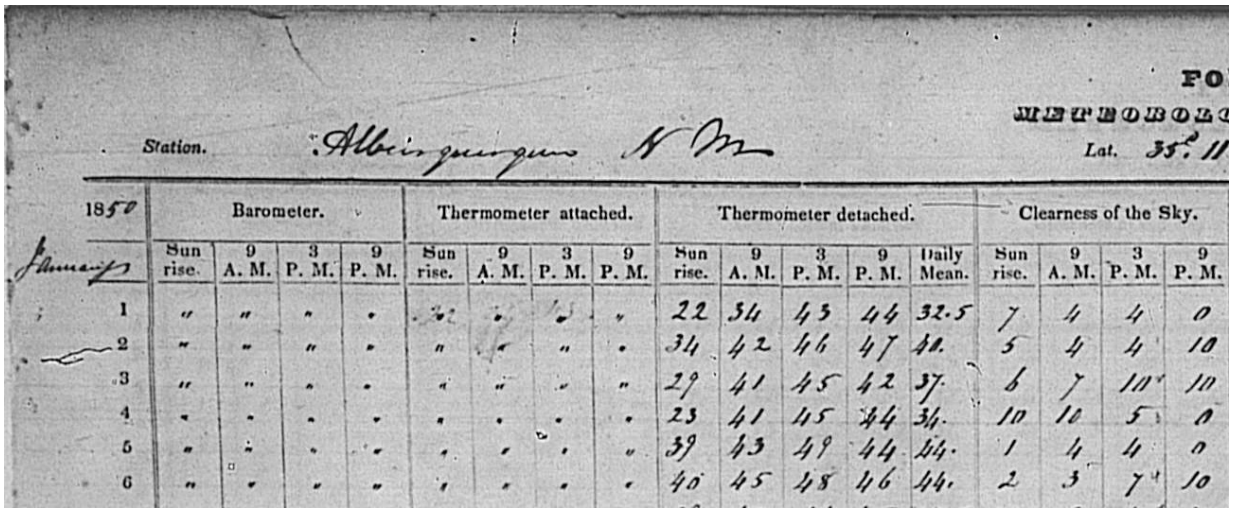
6. CONCLUSION

The “Forts era” weather records of the 1800’s are an invaluable national scientific resource. Through the CDMP Forts project, these records are being made available to the research community for the first time. Numerous scientific endeavors, including those that may help shed light on the ongoing global climate change question, will benefit from this robust data set.

By viewing and keying metadata from each weather form, CDMP meteorologists are establishing a valuable permanent record to be associated with these data. This detailed inspection has also allowed these meteorologists to obtain a unique perspective and understanding of these early observations, their inherent problems and quirks, and hopefully allowed them to preserve some of our Nation’s history in the process.



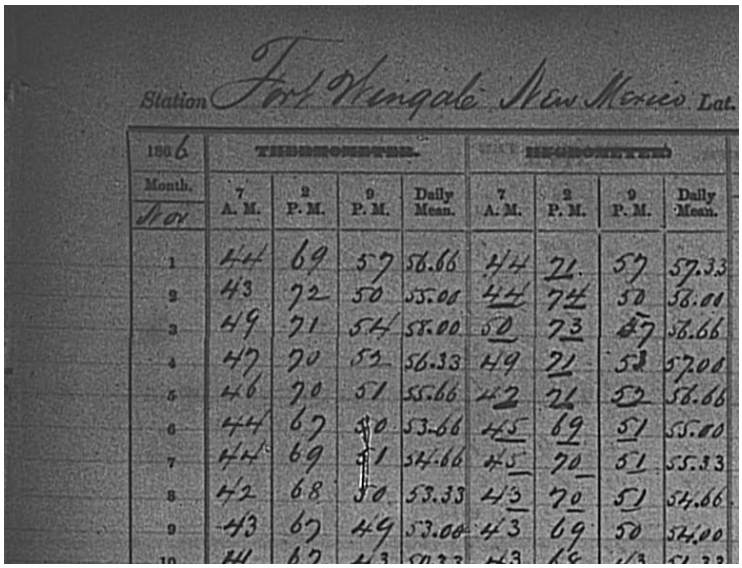
Some of the stations keyed through the CDMP Forts project (as of 11/1/2006)



Station. Albuquerque N Mx Lat. 35.11

1850	Barometer.				Thermometer attached.				Thermometer detached.					Clearness of the Sky.			
January	Sun rise.	9 A. M.	3 P. M.	9 P. M.	Sun rise.	9 A. M.	3 P. M.	9 P. M.	Sun rise.	9 A. M.	3 P. M.	9 P. M.	Daily Mean.	Sun rise.	9 A. M.	3 P. M.	9 P. M.
1	"	"	"	"	"	"	"	"	22	34	43	44	32.5	7	4	4	0
2	"	"	"	"	"	"	"	"	34	42	46	47	42.	5	4	4	10
3	"	"	"	"	"	"	"	"	29	41	45	42	37.	6	7	10	10
4	"	"	"	"	"	"	"	"	23	41	45	44	34.	10	10	5	0
5	"	"	"	"	"	"	"	"	39	43	49	44	44.	1	4	4	0
6	"	"	"	"	"	"	"	"	40	45	48	46	44.	2	3	7	10

"Clearness of the Sky," as observed at Albuquerque, NM in 1850.
The "7" shown for Sunrise means 7/10ths clear, or 3/10ths clouds.



Station Fort Wingate New Mexico Lat.

1866	THERMOMETER.				HYGROMETER			
Month. Nov.	7 A. M.	2 P. M.	9 P. M.	Daily Mean.	7 A. M.	2 P. M.	9 P. M.	Daily Mean.
1	44	69	57	56.66	44	71	57	57.33
2	43	72	50	55.00	44	74	50	58.00
3	49	71	54	58.00	50	73	57	56.66
4	47	70	53	56.33	49	71	53	57.00
5	46	70	51	55.66	42	71	52	58.66
6	44	67	50	53.66	45	69	51	55.00
7	44	69	51	54.66	45	70	51	55.33
8	42	68	50	53.33	43	70	51	54.66
9	43	67	49	53.00	43	69	50	54.00
10	44	67	43	50.33	43	68	43	51.33

Wet bulb temperatures ("Hygrometer" column) higher than
dry bulb, Fort Wingate, NM, 1866.

August, 1790.

Weather			Moon	Remarkable Occurrences
Dull	Clear	Clear		5th – The lottery commenced
Cloudy	Cloudy	Cloudy	Last ¼	drawing –
Dull	Dull	"		12th – The Congress adjour-
"	Clear	"		ned to meet at Philadelphia
Cloudy	"	Clear		on December next –
Clear	"	Dull		13th – The Treaty of al-
Cloudy	Rain	Rain		liance & peace between the
Clear	Showery	Clear		U. S. and Creek Nation was
Rain	Rain	Rain		ratified by the Senate & Pre-
Dull	Clear	Clear	New	sident of the U. S. on one
"	Cloudy	"		part & by Col. Alexander
Cloudy	Clear	"		Mc Gillivray & the Chiefs
Clear	"	"		& warriors of the Creek Na-
"	in the aft. a hard shower	"		tion on the other part at
"	Clear	Clear		the Federal Hall in the
"	Cloudy	"		apartment of the Repres-
"	Dull	Rn & Thun.	First ¼	entatives amidst a vast
Cloudy	Rain	Rain		concourse of spectators —
Dull	Cloudy	Cloudy		
Clear	"	Clear		30th – The President of the
Cloudy	"	"		United States with his fami-
Clear	Clear	"		ly went from this place
"	"	"		to Mount Vernon in Va.

Remarkable weather record from lower Manhattan in New York, dated August, 1790. The observer reports on meetings of Congress and a peace treaty between the United States and the Creek Nations, and notes the departure from the port near his home of President Washington and family to Mount Vernon.

Meteorological Journal

Observatory Washington City July 1st 1842.

Time	Barom.	Thermometers					Dew point	Weather	Portion cloudy	Wind	Force
		Attach.d	Sun	Rad:	Shade	Wet Bulb.					
0h 5'	30.060	83	"	"	79	75	"	Cirrus	4	South	36
2h 5'	30.060	81	"	"	77	72	"	"	5	S. W.	36
3h 5'	30.060	81	"	"	77	72	70	"	6	"	36
4h 5'	30.060	80	"	"	75	70	"	"	7	"	30
6h 5'	30.122	79	82	90	77	75	"	"	4	"	26
8h 5'	30.126	80	95	105	86	83	"	"	4	"	26
9h 5'	30.176	80.2	98	110	86	80	76	"	3	S by W	Calm
10h 5'	30.184	81.7	104	116	86	80	"	"	3	"	"
Noon	30.174	86	98	102	86.5	78	"	Cir Cum	4	"	"
2h 5'	30.156	85	108	116	85.5	78	"	" "	6	"	"
3h 5'	30.156	85.5	110	118	86	76.5	76	" "	7	S W.	"
4h 5'	30.156	85.5	110	118	86	78	"	Cirrus	4	South	Calm
6h 5'	30.146	86.2	100	108	87	78	"	"	4	"	"
8h 5'	30.146	84	"	"	65	78	"	Cumulus	7	Calm	0
9h 5'	30.140	84.5	"	"	85	76.5	78	"	7	"	0
10h 5'	30.186	83.2	"	"	84	76	"	Rain	10	S W	26

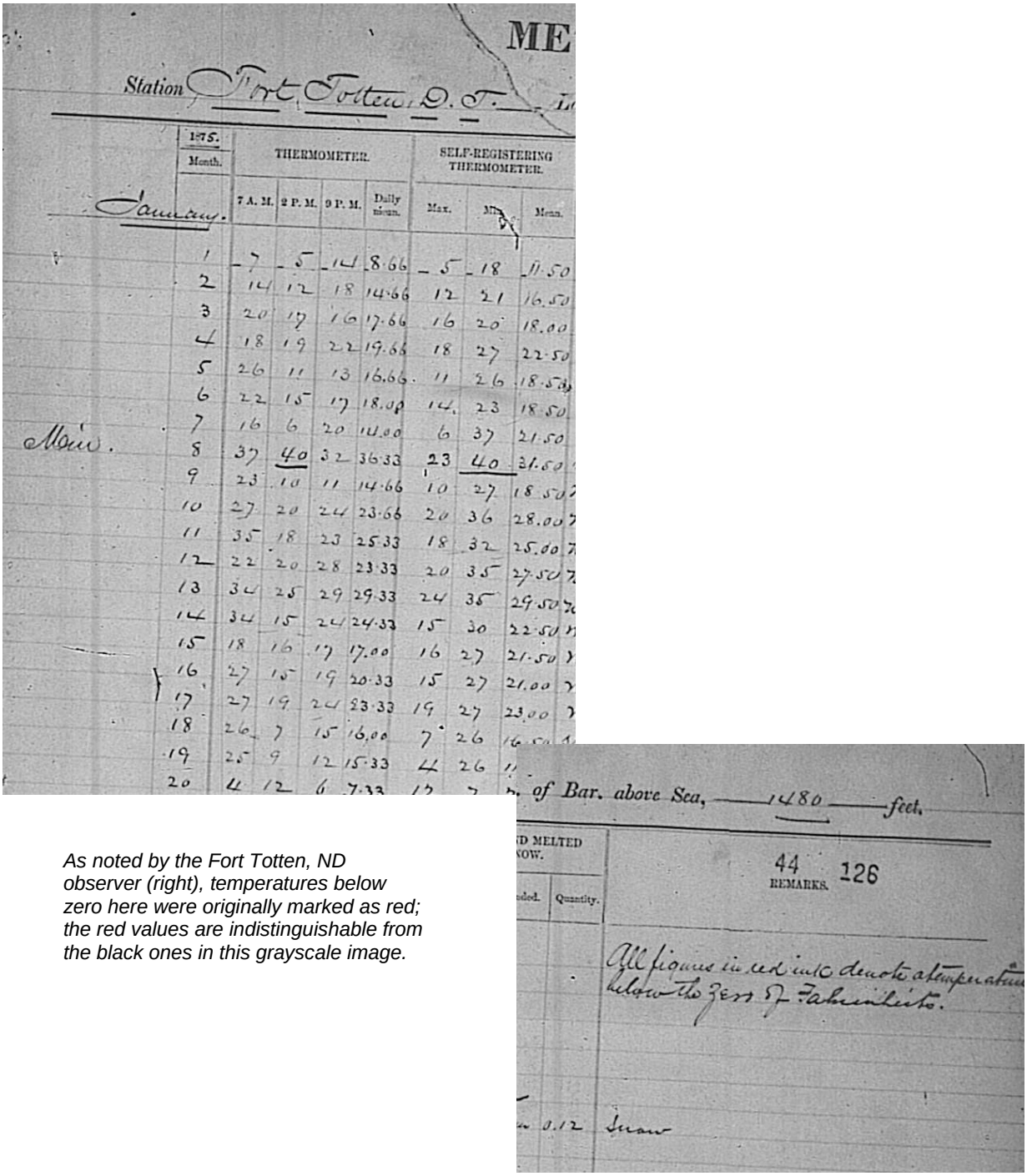
Self Registering Thermometers { Maximum 87°. Minimum 75°.

Rain during the day in .

Remarks

Jos. M. Adams

First observational form from the Washington Naval Observatory, dated July 1, 1842. Note the "Sun" and "Rad" thermometers.



Station Fort Totten, D. T. — Lat.

1875. Month.	THERMOMETER. 7 A. M.	2 P. M.	9 P. M.	Daily mean.	SELF-REGISTERING THERMOMETER. Max.	Min.	Mean.
January. 1	-7	-5	-14	8.66	-5	-18	11.50
2	14	12	18	14.66	12	21	16.50
3	20	17	16	17.66	16	20	18.00
4	18	19	22	19.66	18	27	22.50
5	26	11	13	16.66	11	26	18.50
6	22	15	17	18.00	14	23	18.50
7	16	6	20	14.00	6	37	21.50
Mean. 8	37	40	32	36.33	23	40	31.50
9	23	10	11	14.66	10	27	18.50
10	27	20	24	23.66	20	36	28.00
11	35	18	23	25.33	18	32	25.00
12	22	20	28	23.33	20	35	27.50
13	34	25	29	29.33	24	35	29.50
14	34	15	24	24.33	15	30	22.50
15	18	16	17	17.00	16	27	21.50
16	27	15	19	20.33	15	27	21.00
17	27	19	24	23.33	19	27	23.00
18	26	7	15	16.00	7	26	16.50
19	25	9	12	15.33	4	26	15
20	4	12	6	7.33	12	2	

of Bar. above Sea, 1480 feet.

D MELTED NOW. Quantity.	44 126 REMARKS.
	All figures in red ink denote a temperature below the zero of Fahrenheit's.
	0.12 Snow

As noted by the Fort Totten, ND observer (right), temperatures below zero here were originally marked as red; the red values are indistinguishable from the black ones in this grayscale image.