HISTORY OF WEATHER OBSERVATIONS
MOUNT AUBURN, OHIO
1861 - 1881

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Introduction

Several weather observations were made in the Cincinnati area before those made in Mount Auburn. Among others, there were earlier observations at Fort Washington, those from Dr. Daniel Drake, and those at College Hill. The significance of Mount Auburn was the nature of its data and that it provided daily and monthly entries over a twenty-year period. During that time, the College Hill and Cincinnati stations were also reporting. To climatologists, the existence of Mount Auburn is welcomed because it provides a station whose data can be compared to the other two stations to verify or to call into question those data.

The Mount Auburn data are also valuable because of the credentials of the observers. During almost all of the observational record, there were just three observers. The first two were professors at the Mount Auburn Young Ladies' Institute. This college had a strenuous curriculum particularly in science and mathematics. It was from that part of the faculty that the first observers came. The third was a bookkeeper well suited to an endeavor that required accuracy.

Assessing the natural variability of climate is an essential task before any long-term study can determine whether the climate is changing. The variability of the means and the extremes of a location must be evaluated using climatic data from surrounding stations. That is particularly true of all extreme events. They are unusual by nature and cause concern in the eyes of the public. For example, in the Cincinnati area, reports indicate that frost and ice formed on 2 May 1861, twenty inches of snow fell on 15 January 1863, and temperatures were above 100˚F for four consecutive days with a high of 103˚F in July 1881. Mount Auburn's data are useful in calculating the extent to which variations such as those can be expected to occur.

In every case, the station making the observation must be understood. This study of the history of Mount Auburn weather observations is one way to preserve that history and to help us understand Ohio's climate from its frontier beginning to modern days.

Goal of the Study

The goal of this study is to document the primary weather observational history of Mount Auburn that recorded such an important block of knowledge of early Ohio climate. Climatic data from the weather observations there throughout their period of record are readily available from the National Climatic Data Center, the Midwestern Regional Climate Center, and the State

Climatologist of Ohio. The challenge of this study was to identify Mount Auburn's role in the development of a federal weather observational program and where it fit in the route that followed from the Army surgeons, through the Smithsonian Observers, the Signal Service Observer Sergeants, the Weather Bureau meteorologists, to the National Weather Service observational network of today.

LOCATION OF OBSERVATIONS

According to Cist, the Mount Auburn Young Ladies' Institute was located on a hill north of but within the city limits of Cincinnati. It had a view of the city and its suburbs. It was said to be miles away and "entirely removed from all its contaminating and unhealthy influence." The concern about urban air pollution was already deeply felt and was the cause of some migration away from the downtown area.

The Institute was located on twenty-tree acres of land that was landscaped (Figure 1) by a gardener. Only four acres were cultivated for vegetable and flower gardens and a fruit orchard. The remainder was part of the landscaped area. Therefore, the weather observations recorded there are likely to have been from a good exposure.

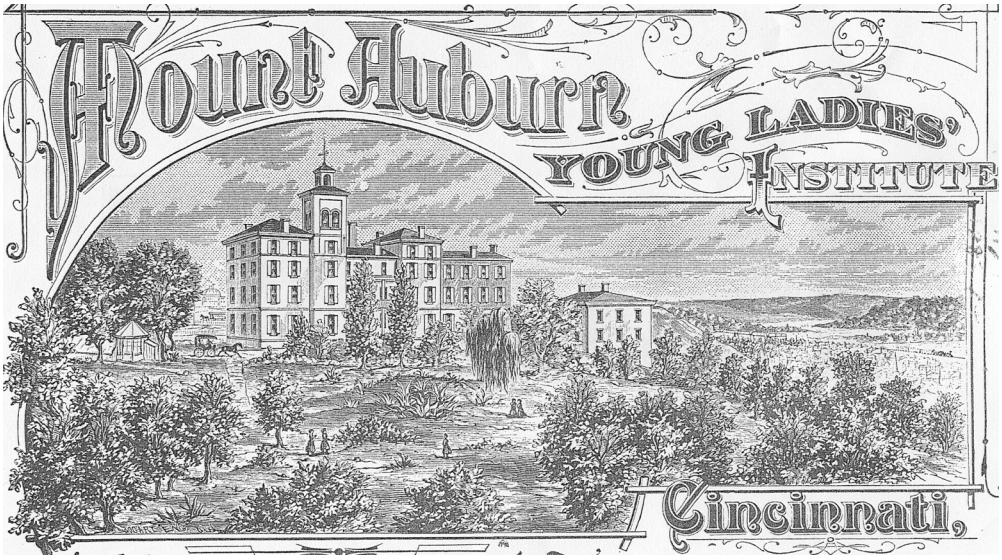


Figure 1. Mount Auburn Young Ladies' Institute
Source: Original Catalog Cover, Cincinnati Public Library

The observation site in 1869 was at 39˚ 07' 08" north latitude and 84˚ 21' 45" west longitude at an elevation of 470 feet above the Ohio River or 1008 feet above mean sea level. The address of the later observations was given as 143 Race Street, Cincinnati.

INSTRUMENTATION

Mount Auburn's observational record tells us something of the type instruments that were used even if not the manufacturer. There was never a listing of equipment or the manufacturers. But, there are other ways to deduce the instrumentation. For example, the first form used was the "Register of Meteorological Observations, Under the Smithsonian Institution, Adopted by the Commissioner of Patents for His Agricultural Report." The instruments, used by the first observer at the Mount Auburn to make entries in all the spaces on the form, included a barometer. He had a thermometer that was attached to the barometer and also an open air thermometer with which to measure temperature. He had a rain gauge too. He was equipped with a hygrometer and recorded dry and wet bulb temperatures for a short time. Those readings were used to calculate the relative humidity.

The information about the instrumentation used at Mount Auburn was recorded as comments regarding some aspect of the observations being made. Nevertheless, those comments tell quite a bit about the equipment. To that end, the following paragraphs are comments taken from the observational forms.

Rain Gauges

There were comments from June 1861 are instructive about the way precipitation was measured.

> The amount of rain on May 31st & June 1st was 1.36 in. The amount for each day is given in proportion to the time.

On the reverse side of the observation form was a space for remarks. Among the remarks for that June were these concerning the rain gauge.

> The amount of rain on the 21st was greater than appears in the record. ... one or two inches. The bottle in the rain gauge was overflowed.

Some rain gauges used a square funnel set flush with ground level that directed the catch into a calibrated bottle beneath. The reference below was made in October 1876 and indicates that the one used at Mount Auburn may have been one of that type.

> I cannot answer your question as to kind of rain gauge. It is an open funnel discharging into a bottle with a graded tube for measuring the water. I purchased it several years since when I was reporting to the Smithsonian Institute & suppose it is accurate enough for all practical purposes.

It does not seem to have been like the one in Figure 2. That was one recommended by the Observer Sergeant Bassler from the Signal Service in Cincinnati.

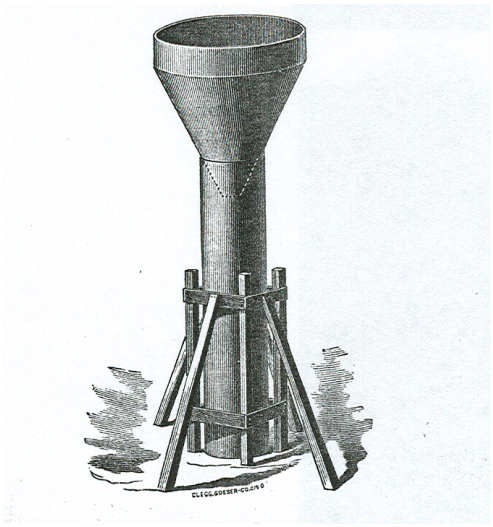


Figure 2. Rain Gauge for Sale circa 1883
Source: The Weather, a Practical Guide, Bassler

Hygrometer

In May 1869, there was a note that the hygrometre (sic) had been broken twice. That occurred during a period when students were making the observations. So much time was lost during its repair that the entire month of data were omitted.

In October 1874, the observer commented to the War Department about his hygrometer.

> I use a hygrometer with a glass retaining tube connecting with the wet bulb by a piece of thin gauze, thus keeping the bulb constantly wet. When below the freezing point this has to be dispensed with. The difficulty of wetting the bulb so as to obtain a satisfactory observation of difference between the wet & dry bulb when very cold, has led me to the inquiry, is there no kind of spirits (alcohol for instance) that would not freeze & yet would give the desired result? Or is there such a natural difference between the temperature of alcohol and water that the result of its use would not be advisable? This may not be a new thought with others.

The description of his hygrometer number 257 is similar to the one (Figure 3) later recommended by Sergeant Bassler in his book.

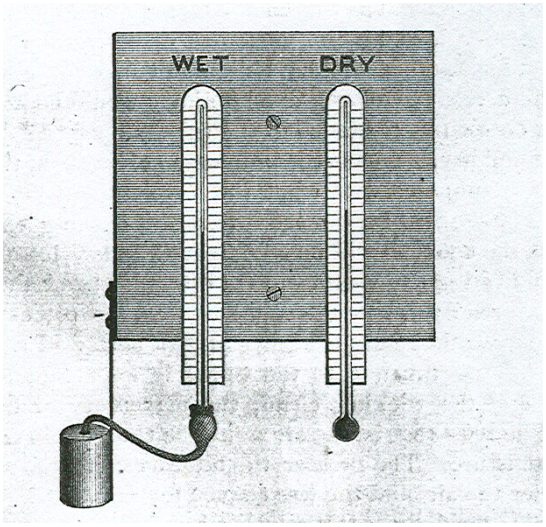


Figure 3. Hygrometer for Sale circa 1883
Source: The Weather, A Practical Guide, Bassler

In February 1880, the observer asked for some help with the calculations of relative humidity.

> The columns for "Dew Point" are imperfect, as Guyots tables do not give the factor below 21 (degrees) and sometimes the factor gives a result greater than the reading. Loomis' Tables give a factor as low as 10 (degrees). His factors do not agree with Guyots, hence I have not used them. Have you any instructions at this point

In March 1880, he discussed the calculations again.

> If you cannot furnish wicking for wet bulb of Hygrometer, please inform me where I can procure some. I received the broad sheet of figures for Dew Point, Humidity &c. If it is intended for use in making up my monthly reports, it will simplify the labor very much. If I understand it the vertical column Headed D.P. is for the Dew Point, but figures given are so different from Guyots tables on XIV page 140 that I hesitated to use it. Example (Guyot) Dry Bulb 60. Diff 5 Dew Point 51. This sheet 56 and there is as great discrepancy in the relative humidity. I do not suppose my reports are of much value anyway but if I make them at all I like to have them as near correct as possible.
> Very Respy, I. H. White

The slowness of communications during this period made resolution of questions such as these difficult.

Barometer

Comments from June 1861 included some insight into the use of the barometer at Mount Auburn.

> The barometrical observations are reduced by use of a table calculated from the expansions of Mercury as given in Ree's Encyclopedia, as we have no copy of the Smithsonian tables.
>
> The monthly means are not given, as it seems desirable that these should be carried to the same degree of approximation by all observers.
>
> The barometrical reductions were made by use of table XVIII. In former months, these reductions were made by a table computed upon the expansion of mercury alone. The averages are therefore too great in these months by from .005 to .015.

In May 1876, the Signal Service provided new instruments except for the barometer. The observer notes that Sgt. "Basford" (read Sgt. Bassler) had spent two days with him to compare barometer readings. He then made this comment.

> In reducing to freezing point I have made the correction which was the difference between mine and Sergt. Basford's (read Bassler's) instrument. Would it be objectionable to move the under plate so as to make it agree with his?

In September 1876, the observer noted that no correction was being made for elevation because of the uncertainty of the station's barometer height above sea level.

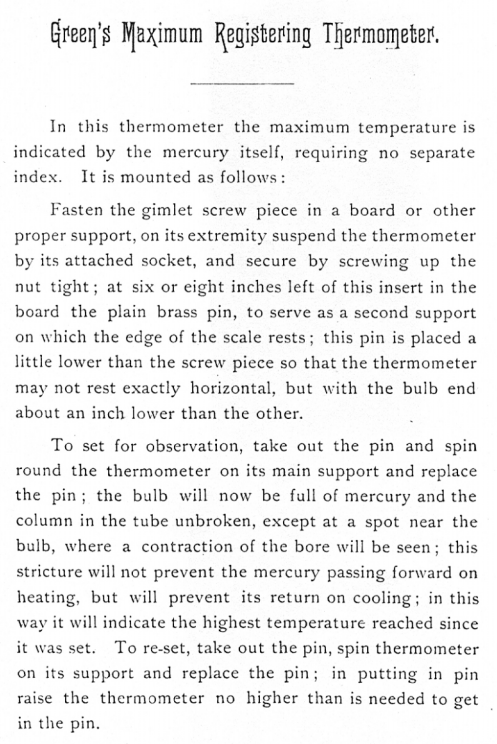
> Barometer corrected for instrumental error & temperature only. I have not the elevation sufficiently accurate to make correction from. It is usually stated at a thousand feet, but judging from Mr. Bassler's Elevation I think it is not more than 900 feet at most 950.

Thermometers

From the beginning of the observations at Mount Auburn, the station had a thermometer to observe the open-air temperature. In October 1874, the observer commented about having maximum and minimum thermometers and was coping with understanding how to use a new form.

> I am not certain that I have filled all the blanks as desired. If by maximum & minimum thermometers is meant the highest & lowest of the exposed thermometers observations, then I have filled the space right. This is my first of this new style of blanks

Then in August 1878 this comment identified the thermometers' maker as Green. A ledger book containing 1884 observations at the Cincinnati Observatory had descriptions (Figures 4 and 5) of the Green maximum and minimum thermometers pasted inside the covers. The Green thermometers were then commonly used.



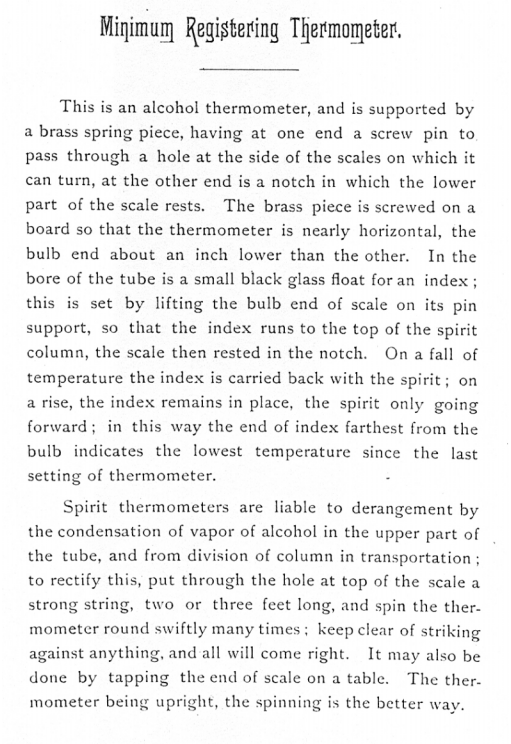
Green's Maximum Registering Thermometer.

In this thermometer the maximum temperature is indicated by the mercury itself, requiring no separate index. It is mounted as follows:

Fasten the gimlet screw piece in a board or other proper support, on its extremity suspend the thermometer by its attached socket, and secure by screwing up the nut tight; at six or eight inches left of this insert in the board the plain brass pin, to serve as a second support on which the edge of the scale rests; this pin is placed a little lower than the screw piece so that the thermometer may not rest exactly horizontal, but with the bulb end about an inch lower than the other.

To set for observation, take out the pin and spin round the thermometer on its main support and replace the pin; the bulb will now be full of mercury and the column in the tube unbroken, except at a spot near the bulb, where a contraction of the bore will be seen; this stricture will not prevent the mercury passing forward on heating, but will prevent its return on cooling; in this way it will indicate the highest temperature reached since it was set. To re-set, take out the pin, spin thermometer on its support and replace the pin; in putting in pin raise the thermometer no higher than is needed to get in the pin.

Figure 4. Instructions for Green's Maximum Thermometer
Source: Thermometer Record Cincinnati Observatory Sep 1 1882-June 30 1884



Minimum Registering Thermometer.

This is an alcohol thermometer, and is supported by a brass spring piece, having at one end a screw pin to pass through a hole at the side of the scales on which it can turn, at the other end is a notch in which the lower part of the scale rests. The brass piece is screwed on a board so that the thermometer is nearly horizontal, the bulb end about an inch lower than the other. In the bore of the tube is a small black glass float for an index; this is set by lifting the bulb end of scale on its pin support, so that the index runs to the top of the spirit column, the scale then rested in the notch. On a fall of temperature the index is carried back with the spirit; on a rise, the index remains in place, the spirit only going forward; in this way the end of index farthest from the bulb indicates the lowest temperature since the last setting of thermometer.

Spirit thermometers are liable to derangement by the condensation of vapor of alcohol in the upper part of the tube, and from division of column in transportation; to rectify this, put through the hole at top of the scale a strong string, two or three feet long, and spin the thermometer round swiftly many times; keep clear of striking against anything, and all will come right. It may also be done by tapping the end of scale on a table. The thermometer being upright, the spinning is the better way.

Figure 5. Instructions for Green's Minimum Thermometer
Source: Thermometer Record Cincinnati Observatory Sep 1 1882-June 30 1884

When the Signal Service forms came into use, there were better records of the instrumentation. The instruments and their serial numbers are shown in Table 1.

Minimum Thermometer	Green, # 4035
Maximum Thermometer	Green, # 3856
Exposed Air Thermometer	# 3723
Barometer	# 2189
Barometer Maker	Joseph Green
Barometer Correction	+0.015
Rain Gauge	Funnel and Bottle
Rain Gauge Maker	J. Foster Jr. & Co
Hygrometer	# 257

Table 1. Instrument Identification at Mount Auburn
Source: Original Observation Records, National Climatic Data Center

THE OBSERVERS

The name Mount Auburn Young Ladies' Institute and the era during which it existed might cause a presumption of poor quality. Quite the opposite of such a presumption was true — the school was of very high quality. According to Cist, the facts were that the Institute was established to:

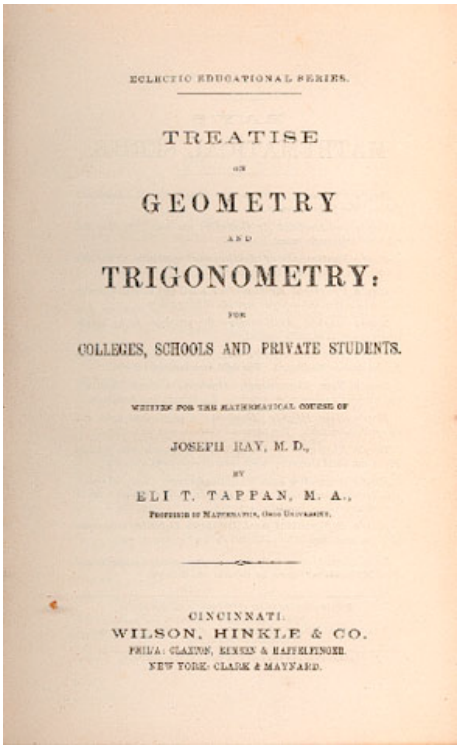
> …. meet a demand long felt in the west for higher female education, equal to that enjoyed at the east, and thus avoid any occasion to send our daughters from home to finish their education, as has been the practice with many of the late years.

Davis states that the Mount Auburn Young Ladies' Institute was established in 1856. The Institute existed and prospered for many years. It developed a national reputation for being one of the best of its kind. The curricula included inter alia science courses such as physics, meteorology, and geology; mathematics courses including calculus, government and constitutional law; languages; literature; music; and art. The Institute had a large collection of mineralogical and geological specimens.

The very first extant observational record from Mount Auburn is for January 1861. The Smithsonian Form had space for forty-eight entries per day. The observer was Eli Todd Tappan (Figure 6).

Figure 6. Eli Todd Tappan, LLD.
Source: David E. Kullman, Miami University

Dr. Tappan joined the faculty of the Mount Auburn Young Ladies' Institute in the fall of 1859. He came from Ohio University were he had been a professor of mathematics. While at the Institute, he wrote a book, "Treatise on Geometry and Trigonometry" (Figure 7).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BY
ELI T. TAPPAN, M. A.,
PROFESSOR OF MATHEMATICS, OHIO UNIVERSITY.

CINCINNATI:
WILSON, HINKLE & CO.
PHILA: CLAXTON, REMSEN & HAFFELFINGER.
NEW YORK: CLARK & MAYNARD.

Figure 7. Eli Todd Tappan's book published in 1867.

The book was written in 1864 for Wilson & Hinkle Publishers for use in a mathematics course taught by Dr. Joseph Ray. Dr. Ray was the first Principal of Woodward High School in Cincinnati but he was more known as the "McGuffey of Mathematics." The reference is to another of the early professors at Woodward, William H. McGuffey, who became famous as the author of the famous Eclectic Readers. Dr. Ray was instrumental in maintaining the weather observations at Woodward High School for the Smithsonian Institute. He may have been an influence on the establishment of the relationship between the Smithsonian and the Mount Auburn Institute.

Whatever the circumstances for becoming a participant in the Smithsonian Institute's climate network and for making the daily observations, Dr. Tappan used the weather station as a teaching tool for the young ladies attending the Mount Auburn Young Ladies' Institute. As a matter of fact, he recorded that he did so with the very first monthly report that he submitted in January 1861 to the Smithsonian.

He made this comment and indicated that he supervised the students.

> The observations were made by the class of Meteorology in the Institute under the direction of E. T. T.

The results of his supervision can be seen in the corrections that he made in the monthly means fro example. At another time during the summer, he had a student named Laura make the observations during July and August 1861. In November 1861, he made a note that the Senior class had made the observations again. He wrote that the calculations, however, were his.

Data are missing for the years 1862-1868. The reason is unknown.

In September 1865, Dr. Tappan returned to being a professor of mathematics at Ohio University. Three years later, he became President of Kenyon College in Gambier, Ohio.

In November 1868, the observations resumed. They were made by the "Young Ladies of the Senior Class of Mt. Auburn Young Ladies' Institute under direction of Prof. S. A Norton." Their January through May observations were copied by I. H. White, proprietor" except for April when his daughter Ann Judson White copied the data onto the submitted form.

Dr. S. A. Norton, A. M,, M.D directed the observations and the calculations during January through May 1869. Almost a year later, his replacement I. H. White, wrote with some exasperation to the Smithsonian about their not noting the change.

> In the monthly Meteorological abstract you still publish Prof. S.A. Norton as observer. He has not been connected with the Institute for nearly a year. Please change the name to I. H. White

In June 1869, Anne Judson White made the entries of the weather observations. The 1880 United States Census lists her as the daughter of Isaac H. White. She did the observations from June through October 1869. She was about seventeen years old during that period. Her youth showed in that she had not yet decided how to sign her name. She wrote it as Anna J, Ann J, Anna Judson, and Miss Anna Judson White. Underneath her name was a note that the "reductions" were made by I. H. White. The October 1869 report was her last. Afterward, her father again made the observations and the reports.

Other changes that affected the observations occurred too. The Signal Service took over the weather observation role from the Smithsonian Institution in 1870 with twenty-four reporting stations. In Cincinnati, the first Sergeant Observer was assigned in 1871 and the earliest of the extant reports from the Signal Service were sent in March 1872. Shortly after the Signal Service started, the observers at Woodward High School ceased sending their reports to the Smithsonian but the observations at College Hill and Mount Auburn continued.

In March 1873, reports began to appear from John Howard Shields who entered "Cincinnati (Mt. Auburn)" as his location. He gave 39˚ 6' north latitude and 84˚ 27' west longitude and an elevation of 940 feet as his position. That longitude and elevation does not

coincide with Mr. White location. Neither did his data. For example, in July 1873, his 7 a.m. temperature was as much as ten degrees cooler than Mr. White's readings. Perhaps the time of his observations were earlier. Like Mr. White, Mr. Shields was entered his observations onto a Smithsonian form. After February 1874, the reports from Mr. Shields stopped. It is clear that the reports from Mr. Shields were not intended as substitutions for Mr. White's but were instead a separate station that also contributed to the Smithsonian.

In November 1873, Mr. White referred to the Signal Service's station in Cincinnati and inquired about the necessity of continuing his observations.

> I have an impression that since the war Signal Service has been in operation in this city. My observations on this hill are comparatively worthless. Unless advised to the contrary I shall close my reports with the present month.

He must have gotten reassurance about the importance of his work because his observations did not stop. Instead, the Mount Auburn station became part of the Signal Service's climate network. In October 1874, the Mount Auburn station began entering its observations on the War Department Form E.

The Form E required observations three times per day and he was observing at 7 a.m., 2 p.m., and 9 p.m. He entered the barometer reading in inches and tenths; the exposed thermometer reading in Fahrenheit; wind direction in cardinal points and the coded wind force; the low cloud type and sky coverage in tenths, the upper clouds type, coverage, and direction of movement; the beginning and ending times of rain and snow; the amount of rain or melted snow; the daily mean barometer and temperature means; the type of weather, and remarks.

The old Smithsonian Register of Meteorological Observations form had needed 27 entries per day. The new Signal Service form had space for 69 entries per day.

Mr. White did not have the opportunity to be trained as the Army Sergeants were. Goodwin's study described the "school of instruction" located at Fort Whipple (later renamed Fort Myer) in Virginia. General Myer, Chief Signal Officer after the Civil War, created that weather school in 1870. The school trained the Signal Service observers in both weather observation and in telegraphy. The simultaneous transmission of weather observations from the observers to Fort Whipple permitted the evolution of daily weather maps.

From the beginning, the Signal Service station at Cincinnati was very active. It received daily reports from fifty-three other stations and those data were used to prepare issued eleven daily bulletins. They also provided tables of weather data to five daily newspapers, several libraries, the Chamber of Commerce, and the Board of Trade. The daily newspapers published the daily weather reports with attribution to the Signal Service.

A new changed War Department's Form H was first used at Mount Auburn in May 1876. The Signal Service was changing too. By 1878, the total number of Signal Service reporting locations had increased to seventy-eight nationwide. Three times each day (usually 7:35 a.m.,

4:35 p.m., and 11:35 p.m.), each station telegraphed their observations to Washington, D.C. These observations consisted of:

> Barometric pressure and its change since the last report.
> Temperature and its 24-hour change.
> Relative humidity.
> Wind velocity.
> Pressure of the wind in pounds per square foot.
> Amount of clouds.
> State of the weather.

In September 1879, Mr. White began using a new Signal Service reporting form. It was a named "Voluntary Observer Meteorological Record." It still required the three times daily observations of the temperature, precipitation information, the clouds and sky conditions, the wind information, barometer information, and humidity and dew point information. There was a monthly climatological summary added with the requirements for reports of the dates of thunderstorms, the number of precipitation days, the highest and lowest temperature of the month, and other such types of climatological summations.

Mr. White was a dependable observer. He was especially reliable when he thought conditions needed an explanation or amplification. His quantitative measurements were frequently accompanied with comments that provided a qualitative measurement as well. However, with all the notoriety being enjoyed by the Signal Service in Cincinnati, Isaac H. White at Mount Auburn began to feel neglected and unappreciated. In January 1881, he wrote about his feelings.

> If my "Casual Phenomena" are worth noting at all - Is there any
> objection to noting them as "Mt. Auburn" and not as "Cincinnati"
> Although in the City limits, Prof. Abbe knows we are so far distant
> and elevated as to hardly be counted in the city. Besides this I take
> some pride in my work and when noted as Cincinnati, my own
> friends & others think
> of nothing but the signal service Station.
> truly yours, I. H. White

The reference was to Professor Cleveland Abbe, the Director of the Cincinnati Observatory, who would become the father of the Weather Bureau. Between Professor Abbe's and the Signal Service's pursuit of publicity and their national renown, the lack of acknowledgement of Mr. White's contributions was probably real. Even the United States Census of 1880 listed his occupation as "Book Keeper."

THE END OF MOUNT AUBURN"S CLIMATE OBSERVATIONS

Isaac H. White continued as an observer for the Signal Service's meteorological network through May 1881. After more than thirteen years of daily observations, his last report made no mention that it was the last.

So ended a long and valuable record of the variability of climate during the developmental period not long after the early settlement of the Old Northwest. One can't help but be proud that all of the people involved recognized the value of these weather records and preserved them with care.

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APPENDIX 1

METHODOLOGY

The primary sources of information for this study were the Mount Auburn, Ohio and other Hamilton County observers' daily weather records themselves. Copies of their monthly reports and the data digitized from those reports were available from the Midwestern Regional Climate Center in Champaign, Illinois, or the National Climatic Data Center in Asheville, North Carolina. The monthly reports can be considered original sources because they were written by the observers and not altered by subsequent readers.

There were a variety of secondary sources that held information about Mount Auburn, its history, and its people. The author visited and collected information from the holdings of the Kentucky Climate Center and the Kentucky Library at Western Kentucky University in Bowling Green, Kentucky; and the National Climatic Data Center at Asheville, North Carolina. The primary historical sources were the Cincinnati Public Library, the Cincinnati Historical Society Library, and the University of Cincinnati Archives. The LDS Family History Library in Salt Lake City, Utah was visited as well. The National Weather Service Office in Wilmington, Ohio, especially Sam McNeil, was most helpful.

The tertiary sources were reference materials that are available on-line. Among those were the metadata prepared by the Office of the State Climatologist of Ohio, Midwestern Regional Climate Center, the National Climatic Data Center substation histories, and the Signal Service records of the U.S. Army. Two genealogical research sources, Ancestry.com and Genealogy.com were used to provide some of the personal information about the observers. For location analysis, the interactive maps available from TopoZone.com were used.

There was an attempt to glean information from all these sources that would allow a glimpse into the lives of the observers, the location of the observation site, and the historical environment that produced the climatic history of Mount Auburn, Ohio. Maps, drawings, and photographs were included when appropriate to illustrate the information.

Throughout the research for and preparation of this study, the objective was to produce a document that future studies can use to evaluate the validity of the data that were collected here, judge the trustworthiness of the observers who collected them, and determine the climatological significance of the whatever variability may be discerned.