A Review of Weather Observations at the Blue Hill Observatory During the North American Total Solar Eclipse of 8 April 2024

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The total solar eclipse that traversed the United States on 8 April 2024 was a widely anticipated celestial event that was enjoyed by millions of people and provided a rare opportunity to experience one of the many dazzling wonders of our solar system. Although clouds obscured the view of totality for some, many witnessed the unusual sight of the Sun's corona and solar prominences along the path of totality that extended from Mexico northeastward through Texas, Indiana, western New York state, central Maine and into Maritime Canada (Figure 1). All of the rest of the United States was under the shadow of a partial solar eclipse for a few hours, and the shadow of the Moon that was caused by totality (umbra) and by the partial eclipse of the Sun (penumbra) was visible from space as it rapidly crossed the country (Figure 2). At the Blue Hill Observatory (BHO) on the summit of Great Blue Hill in eastern Massachusetts, the eclipse began at 18:16 UTC (2:16 PM EDT) and ended at 20:39 UTC (4:39 PM EDT). The peak obscuration of the Sun was 92.0% (at 3:29 PM EDT), which provided a dramatic darkening of the sky that lasted long enough to impact several of the weather parameters observed at BHO. This report summarizes the weather changes that were recorded at BHO during this solar eclipse.

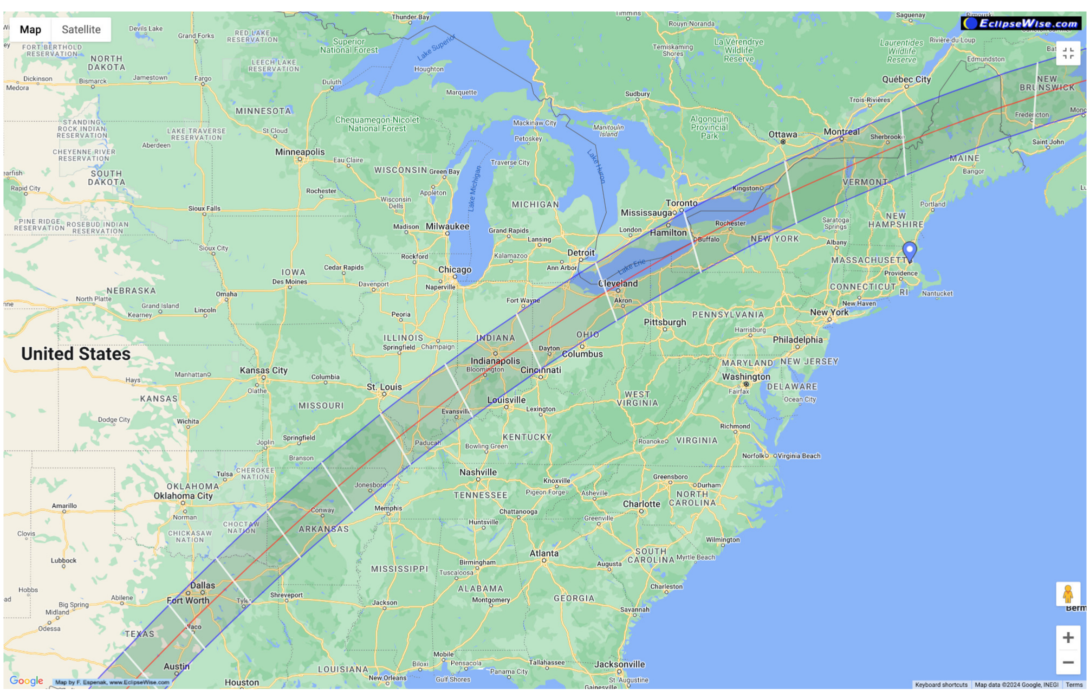

Figure 1. Map of the path of totality of the solar eclipse of 8 April 2024. Blue pin marks the location of the Blue Hill Observatory in eastern Massachusetts. Map provided by eclipsewise.com and Google maps.

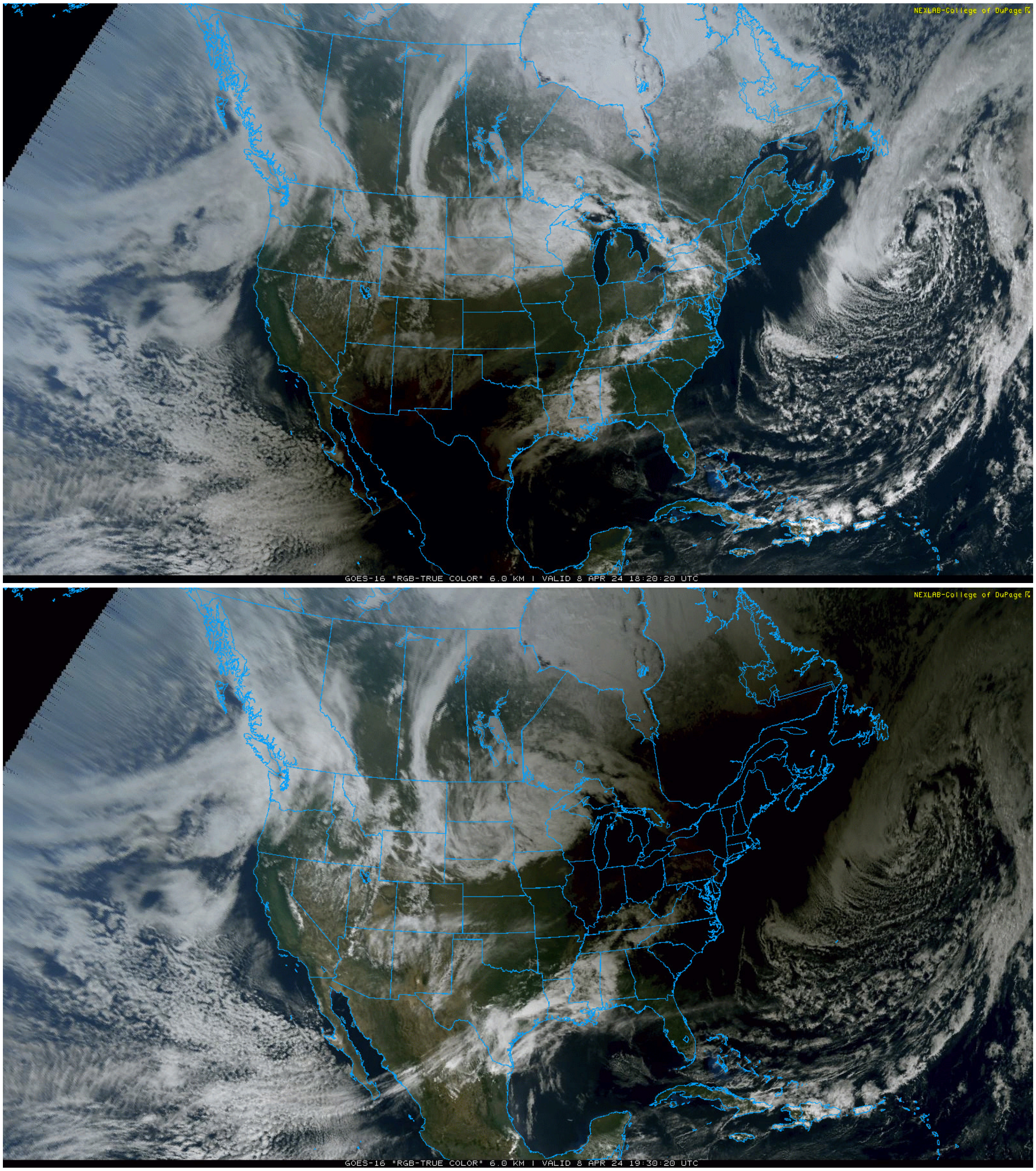

Figure 2. GOES-16 true-color visible satellite imagery over North America on 8 April 2024 at 18:20 UTC (2:20 PM EDT, top image) and at 19:30 UTC (3:30 PM EDT, bottom image) during the total solar eclipse on that date showing the lunar shadow centered over Mexico and Texas (top) and centered over the eastern United States (bottom). Satellite imagery courtesy of the College of DuPage Weather Lab (weather.cod.edu).

Sunshine

The most direct impact of the solar eclipse on the BHO weather observations was on the recordings of sunshine duration and surface solar radiation intensity. Daily sunshine duration is measured with a Campbell-Stokes sunshine recorder, which uses a solid glass sphere to focus direct sunlight to a very bright spot onto a treated, narrow paper card positioned at the focal length of the glass. As the Earth rotates during the day (and the Sun traverses the sky), the card is scorched when the intensity of sunlight is greater than a specific intensity (roughly 120 Wm^{-2}), which leaves a permanent record along the card that is later converted to the duration of "bright" sunshine in minutes. The observed duration is also converted to a daily percent of possible relative to the maximum time that the Sun can burn the card each day. BHO also maintains a solar radiometer that takes continuous measurements of the surface solar radiation intensity, which is very sensitive to solar obscurations such as clouds and aerosols.

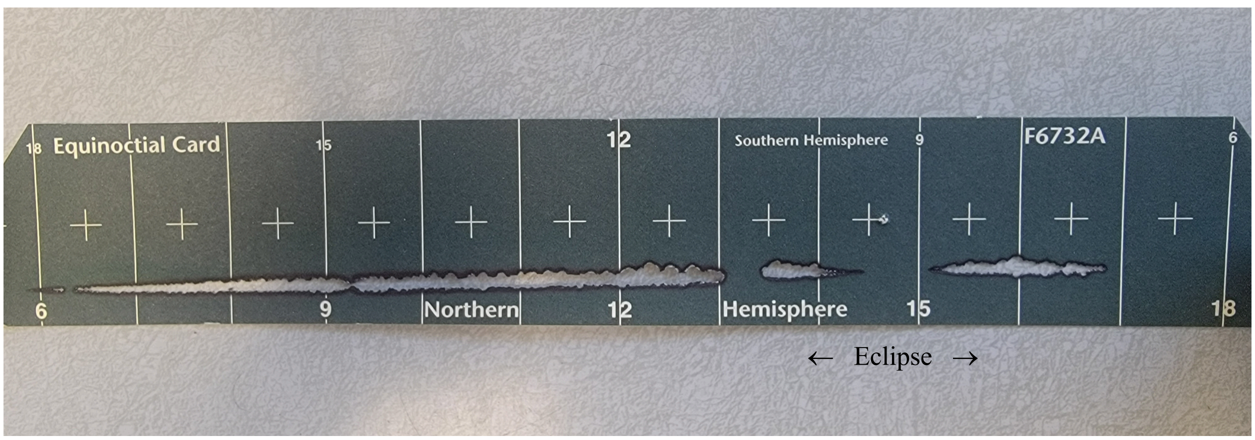

Figure 3. Campbell-Stokes sunshine recorder card showing the measurement of sunshine duration at BHO for the afternoon of 8 April 2024 (right side of card after 1330 solar time) and the morning of 9 April 2024 (0600 to 1300 solar time). The gap in the burn mark between 1427 and 1507 local solar time records the loss of bright sunshine during the partial solar eclipse. The approximate full extent of the eclipse is marked with arrows.

The drop in sunlight during the eclipse was very apparent in measurements taken with the BHO sunshine recorder, and the sun card from that day is shown in Figure 3. The card is marked in hours (0600 to 1800), and the length of the burn mark across the bottom of the card is the record of bright sunshine duration, which is recorded in local solar time. The width of the burn mark is roughly proportional to the intensity of the direct sunlight. Sunshine observed during the afternoon of 8 April 2024 is on the right side of the card (after 1330 solar time), and sunshine observed during the morning of 9 April 2024 is on the left side of the card (from 0600 to 1300 solar time). The gap in the burn mark between about 1427 and 1507 local solar time is the interval of the full loss of bright sunshine during the partial solar eclipse, while the decrease in the width of the burn on either side of this gap records the reduced sunshine during the periods of less solar coverage. Each day, an adjustment, which varies throughout the year depending on the relative positions of the Earth and the Sun, is applied to the sunshine data to convert local solar time on the sun card to local standard time for permanent recording of the data, and the adjustment for April 8 is -13 minutes. Applying this adjustment gives an interval of 1414 to 1454 eastern standard time (EST), which roughly straddles the time of peak solar coverage at 1429 EST. It should be noted that a veil of high clouds was also overhead during much of the eclipse at BHO, and this added obscuration likely reduced the bright sunshine and altered its variability slightly relative to a fully clear sky during this time.

A Davis Vantage Pro automated instrument system, which has been in continuous use at BHO since 2004 to provide an unofficial set of weather observations for educational and scientific purposes, includes a solar radiometer, which collected measurements at high temporal resolution (one-minute) of solar intensity during the eclipse. The record of solar intensity (in units of Wm^{-2}) from this instrument for the entire calendar day of 8 April 2024 is shown in Figure 4. The increasing intensity between about 0600 EST and 1200 EST indicates the advance of the Sun to its highest point in the sky with little obscuration during the morning. High clouds began to obscure the sunlight somewhat before 1300 EST, and the dramatic drop in solar intensity due to the eclipse is apparent from about 1330 EST to 1530 EST with the minimum intensity (of less than about 50 Wm^{-2}) occurring around 1430 EST near the peak solar coverage during the eclipse.

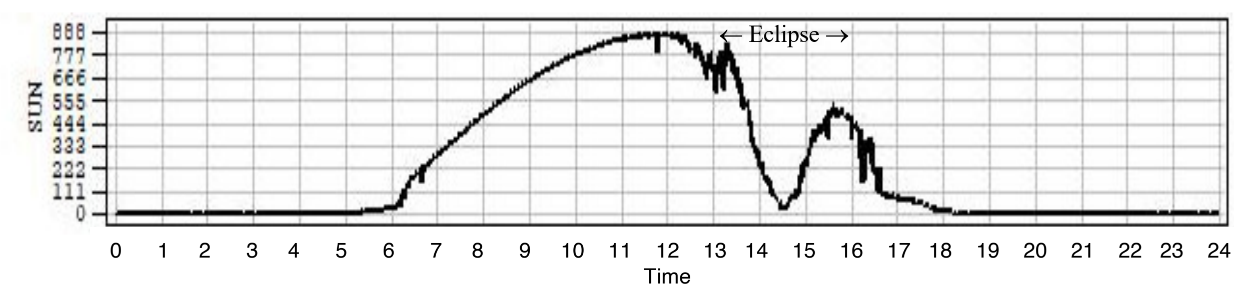

Figure 4. Surface solar intensity as observed by the Davis Vantage Pro radiometer at BHO for the entire calendar day on 8 April 2024. Vertical lines mark each hour in EST. Intensity units are in Wm^{-2}.

The expected solar intensity burn threshold of the sun card (about 120 Wm^{-2}) was roughly consistent with the Davis radiation measurements during the eclipse. The loss of burn on the sun card at about 1414 EST (see Figure 3) and the continuation of burn on the sun card at about 1454 EST correspond to a radiometer measurement of approximately 130-140 Wm^{-2} at those times (see Figure 4).

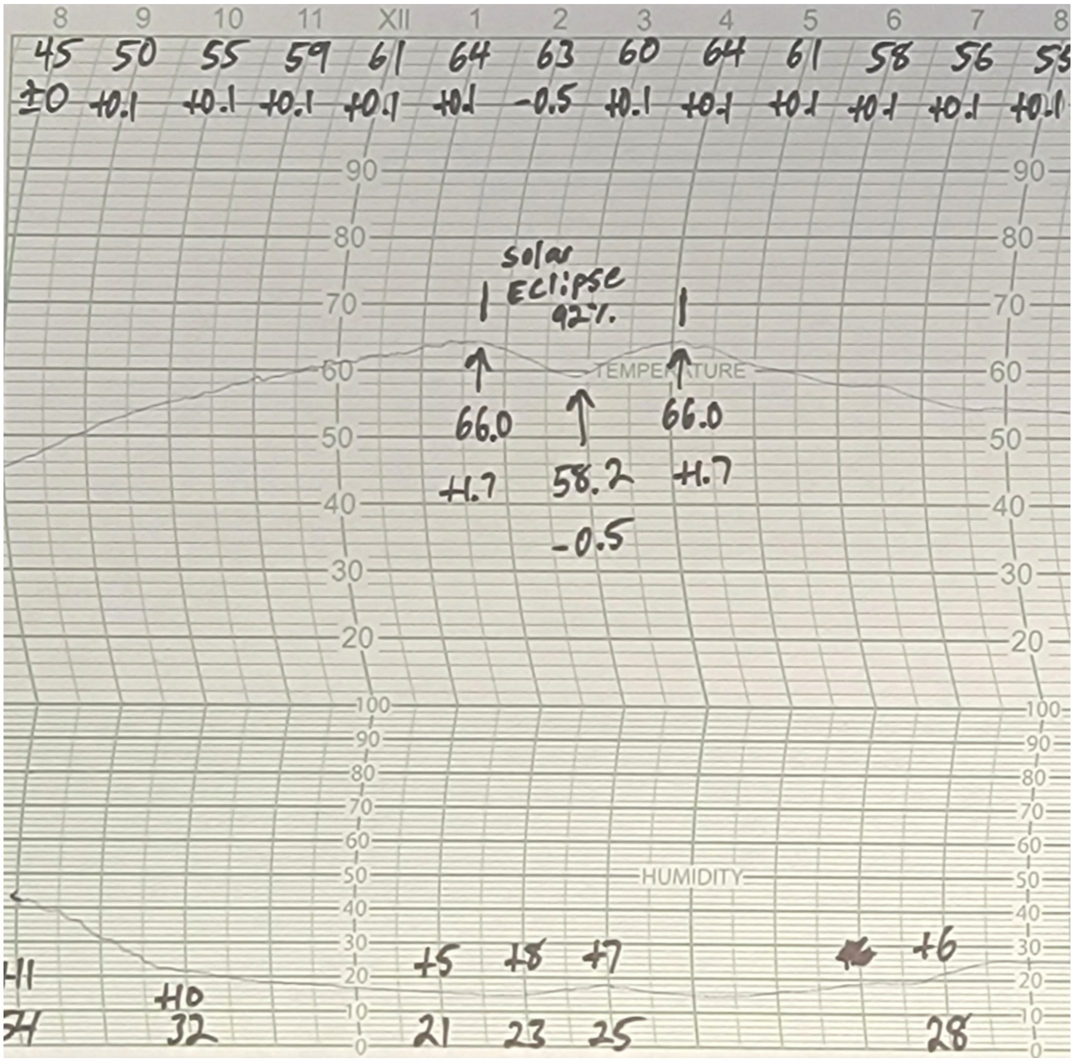

Figure 5. Hygro-thermograph chart recording of temperature (top trace) and relative humidity (bottom trace) as recorded at BHO on 8 April 2024. Printed numbers at top are hour markings (8 AM to 8 PM EST), hand-written numbers at top are observed or derived hourly temperatures (and chart corrections), and written numbers at bottom are observed or derived relative humidity values (and chart corrections). Hand-written numbers at center are maximum and minimum temperatures observed before, during and after the solar eclipse between 1330 and 1630 EST. Temperature units are in deg F and relative humidity units are in percent.

Temperature and Relative Humidity

The drop in solar heating during the eclipse caused widely observed temporary changes in surface temperature under the rapidly moving lunar shadow, and this effect was also recorded at BHO. In addition to manual, periodic psychrometric measurements of dry bulb and wet bulb temperature (from which the dew point, relative humidity, and vapor pressure are derived), continuous chart recordings of temperature and relative humidity (RH) are collected at BHO each day using a Belfort hygro-thermograph, which is used to derive hourly temperatures and six-hourly RH data that are not observed manually. The BHO hygro-thermograph continuous temperature and RH chart recording for 8 April 2024 is shown in Figure 5 for the period from 8 AM EST to 8 PM EST. Printed numbers at the top of the chart are hour markings, hand-written numbers at top are observed or derived hourly temperatures (and chart corrections), and written numbers at bottom are observed or derived relative humidity values (and chart corrections). Hand-written numbers at center are maximum and minimum temperatures observed before, during and after the solar eclipse during the period from 1330 and 1630 EST. Figure 5 shows a total drop in temperature of eight deg F from 66F to 58F, followed by a rise of eight deg F back to 66F at the end of the eclipse. Note that the time of the lowest temperature during the eclipse at about 1450 EST was delayed by about twenty minutes after the time of the maximum solar obstruction by the Moon at 1430 EST. The air was very dry on this afternoon, in part due to the relatively warm temperatures, and in parallel with the temperature drop the RH increased by about two percent from 23 to 25 percent before retreating again once the temperature climbed for a short time after the eclipse before dropping as evening approached. Unofficial, automated temperature, dew point, and RH measurements by the Davis instrument system at BHO for 8 April 2024 are shown in Figure 6. The Davis data also show a drop in temperature of about 8 deg F and a recovery of about the same magnitude, a temporary increase in RH of about ten percent, and only small changes in dew point during the eclipse. Figure 6 places the changes caused by the eclipse from about 1330 to 1630 EST in the context of changes over the entire day.

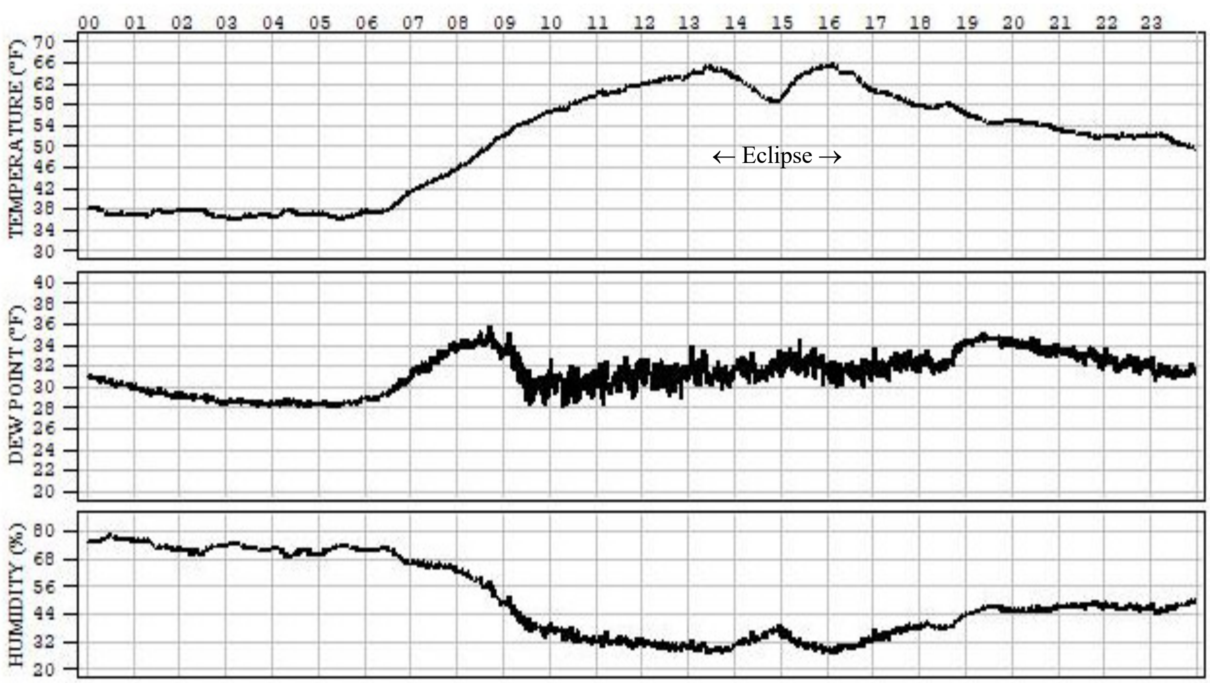

Figure 6. Unofficial surface temperature, dew point, and relative humidity as observed by the automated Davis instrument system at BHO for the entire calendar day on 8 April 2024. Vertical lines mark each hour in EST. Temperature and dew point units are in deg F, and relative humidity units are in percent.

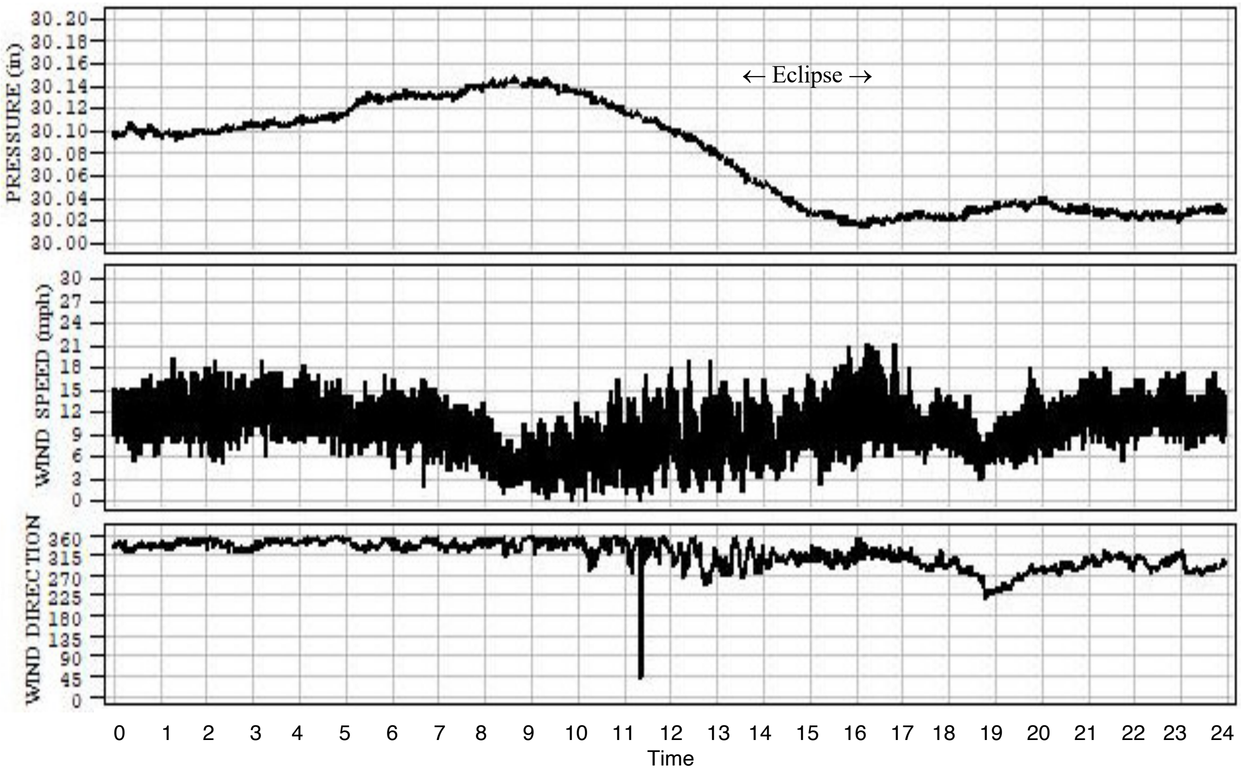

Figure 7. Unofficial surface pressure, wind speed, and wind direction as observed by the automated Davis instrument system at BHO for the entire calendar day on 8 April 2024. Vertical lines mark each hour in EST. Surface pressure units are in inches, and wind speed units are in miles per hour.

Wind Speed and Direction

Eclipse induced changes in wind speed and direction could possibly be caused by the movement of air from the sudden cooling within the lunar shadow that may cause air to descend and spread outward perpendicular to the path of totality. The unofficial automated observations of one-minute wind speed (in mph) and wind direction measured by the Davis system at BHO are shown in the center and bottom panels of Figure 7. The wind speed was generally very light all day, though the wind speed increased slightly during the eclipse period, and the official peak wind gust for the day (as derived from the 420C wind gust chart recorder at BHO) was 23 mph from the west-northwest (WNW) at 1620 EST near the end of the eclipse. The wind direction remained generally from the west-northwest to northwest during the early afternoon, so any eclipse induced wind shift from the direction of the path of totality can't be isolated from the background wind movement. However, although a strong signal isn't apparent, it's plausible that the eclipse contributed to increasing the wind speeds slightly at BHO for a short time, but these could also be due to unrelated, ongoing changes in surface pressure.

Surface Pressure

The synoptic pattern on 8 April 2024 included a ridge of high pressure extending from Quebec southward down the U.S. East Coast, with a weak warm front and associated clouds moving through the eastern Great Lakes and New York state (see top panel of Figure 2). This pattern produced the veil of high clouds that moved into southern New England during the day. The one-minute observations of surface pressure (in inches) measured by the Davis system at BHO on this day are shown in the upper panel of Figure 7. The pressure data show a peak occurring at mid-morning (around the time of the typical peak in the small, regular diurnal surface pressure variation) followed by a slow drop in pressure until about 1600 EST with steadier pressure for the rest of the day. While there is a slight increase in the rate of the pressure fall during the eclipse that could reflect the additional movement of air during the eclipse, the signal is too weak to clearly isolate the cause from the background synoptic pressure changes.

Eclipse Experiences

The last total solar eclipse to pass directly over Great Blue Hill occurred on Monday, 16 June 1806, which was well before the founding of the Observatory, though there are contemporary accounts from those who witnessed it. Since then, several paths of totality have come very close to Great Blue Hill. Table 1 lists the most notable total and annular solar eclipses (with obscuration of the Sun of 80% or more) since the late 18th century. The next closest, on 2 October 1959, was technically total over Boston and 99.9% over the Observatory, but it occurred with the sun on the horizon at sunrise and so it was likely not noticed by most people. BHO records include observations during all of the events since 1900 listed in Table 1, including many others not listed in which the Sun was less obscured by the Moon. Comprehensive research and analysis was done following the solar eclipse on 31 August 1932, which was very close to total at BHO (*Conover*, 1990; *Brooks, et al.*, 1941). Multiple established and temporary observing sites were set up in the path of totality from

Eclipse Date	Eclipse Type	Solar Obscuration at Great Blue Hill
1778, 24 June	Total	92.1 %
1806, 16 June	Total	100.0 %
1811, 17 September	Annular	85.0 %
1831, 12 February	Annular	93.8 %
1834, 30 November	Total	84.3 %
1869, 7 August	Total	81.4 %
1900, 28 May	Total	90.9 %
1925, 24 January	Total	99.5 %
1932, 31 August	Total	99.6 %
1959, 2 October	Total	99.9 %
1963, 20 July	Total	93.0 %
1970, 7 March	Total	96.8 %
1994, 10 May	Annular	87.3 %
2024, 8 April	Total	92.0 %

Table 1. Notable total and annular solar eclipses and the maximum obscuration (> 80 %) at Great Blue Hill since 1778.

Canada through far eastern New England for this eclipse that included measurements taken at the surface, aboard aircraft, and from balloons. While clouds interfered with the observing at some locations, it was noted that some low-level cumulus dissipated during the eclipse while the temperature dropped from 2 to 11 deg F depending on the location (*Brooks*, 1932).

Figure 8. Photographs of public eclipse viewing on Great Blue Hill (top) and of the partial solar eclipse (bottom) on 8 April 2024. Photos by BHO observer Amanda Joly.

During the 8 April 2024 eclipse, the Observatory hosted a viewing event for dozens of people, during which BHO staff collected observations, interpreted the event and answered questions of visitors, and took many photographs. Figure 8 shows the attendees viewing the eclipse behind BHO on the summit of Great Blue Hill (top) and two photographs (bottom) of the partial eclipse including one near the time of maximum solar obscuration.

Acknowledgments

The authors acknowledge the contributions of Blue Hill Observatory staff who participated in the eclipse monitoring and weather observing as well as the assistance of Dan Hansen who maintains the Davis Vantage Pro instruments at BHO and who provided data from that system for this report. For more information about the Blue Hill Observatory measurements, observing practices, history and educational programs, visit the Observatory web site at bluehill.org.

Eclipse Resources

Past and Future Eclipse Information and Interactive Maps: https://www.eclipsewise.com
General Information: https://greatamericaneclipse.com
Scientific Information: https://science.nasa.gov/eclipses/

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Brooks, C.F., The Total Solar Eclipse of August 31, 1932, *Bull. Amer. Meteor. Soc.*, 13, 159-160, 1932, https://doi.org/10.1175/1520-0477-13.8-9.159.

Brooks, C.F., S.P. Fergusson, H.H. Kimball, B. Haurwitz, E.S. Brooks, J. Namias, C.H. Pierce, H Wexler, and E.M. Brooks, Eclipse meteorology with special reference to the solar eclipse of August 31, 1932, *Harvard Univ. Meteor. Studies*, No. 5, Cambridge, MA: Harvard University Press, 109 p., 1941.

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