Stratospheric Ballooning Investigation of the 2023 and 2024 Eclipses

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Abstract

The St. Catherine University High Altitude Ballooning (HAB) team plans to investigate the 2023 annular and 2024 total solar eclipses to observe stratospheric changes in the atmosphere during these events. The summer of 2020 was used by our team to plan out launch location areas, exploring higher education institution locals to partner with within the path of obscuration, and better understanding the different types of eclipses. We will observe the 2023 annular eclipse in the San Antonio, Texas area and the 2024 total solar eclipse in the Indianapolis, Indiana area. The investigations into these eclipses will obtain measurements for temperature, pressure, charged cosmic rays, and uncharged cosmic rays. Stratospheric changes such as the cosmic ray flux and the altitude of the tropopause, both which influence upper atmospheric weather, are important measurements to be recorded during these celestial events. The 2023 annular and the 2024 total solar eclipses provide a unique opportunity to measure stratospheric changes during these eclipses that are important to organizations such as NASA and NOAA.

Background

The two types of eclipses that will be researched are an annular solar eclipse in 2023 and a total solar eclipse in 2024. An annular solar eclipse occurs when the Moon passes between the Earth and the Sun, but it does not completely obstruct the view of the Sun. The small amount of light that is seen during an annular eclipse is due to the Moon being further from the Earth than it is during a total solar eclipse. The ring of light that is seen from the Sun that the Moon does not completely obstruct is called the annulus [1]. A total solar eclipse occurs when a new Moon passes between the Earth and the Sun, completely obstructing the view of the Sun from the Earth. During a total solar eclipse, the Moon is closer to the Earth than during an annular solar eclipse, which allows it to completely obstruct the view of the Sun from Earth [2].

There is a difference in the amount of light that is seen during an annular solar eclipse and a total solar eclipse; this causes multiple types of shadows to occur. These shadows are called the umbra, penumbra, and antumbra; they arise at different periods during each eclipse [1]. The umbra is created from the Moon obstructs the Sun, it is able to be seen in the path of totality and is the darkest shadow. The penumbra is the type of shadow that surrounds the umbra, it is seen in locations that are not in the path of totality. The antumbra occurs only during annular eclipses and it is the shadow that extends beyond the umbra. It is similar to the penumbra in that there is still light seen from the Sun, this is due to the distance that the Moon is from the Earth. The antumbra occurs within the path of totality [2]. Annular and total solar eclipses have contact periods, they are the different phases of the Moon obstructing the Sun [3]. Figures 4 and 5 label each contact phase of annular and total solar eclipses. Figure 1 is a data table with logistical information for each eclipse. The 2023 annular and 2024 total solar eclipses offer a unique opportunity to investigate eclipse data.

Table 1 Eclipse data table [3]

Location:	San Antonio, Texas	Indianapolis, Indiana
Date:	October 14th, 2023	April 8th, 2024
Time Zone:	Central Daylight Time	Eastern Daylight Time
Maximum Time:	4 minutes 22 seconds	3 minutes 50 seconds
Maximum UTC:	16:54:16	19:07:56
Full Begins:	11:52:05 am	3:06:01 pm
Maximum Peak:	11:54:16 am	3:07:56 pm
Full Ends:	11:56:27 am	3:09:51 pm
Coverage:	90.16%	100.00%

Eclipse Maps

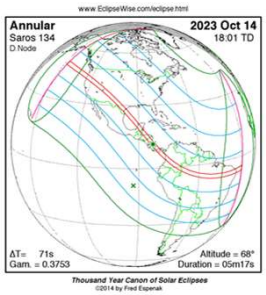
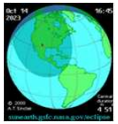
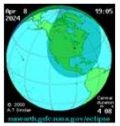


Figure 1 Eclipse path map for the 2023 Annular Solar Eclipse [4].



The Annular Solar Eclipse of 2023 [5] is portrayed in an image from the path map as seen above. The QR Code [6] for the full animation is below.

The Total Solar Eclipse of 1999 [7] is portrayed in a still image as seen above. The QR Code [8] for the full animation is below.



The Total Solar Eclipse of 2024 [9] is portrayed in an image from the path map as seen above. The QR Code [10] for the full animation is below.

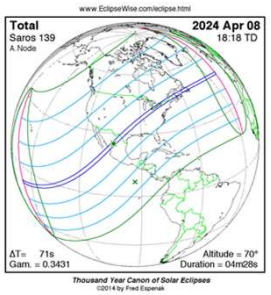


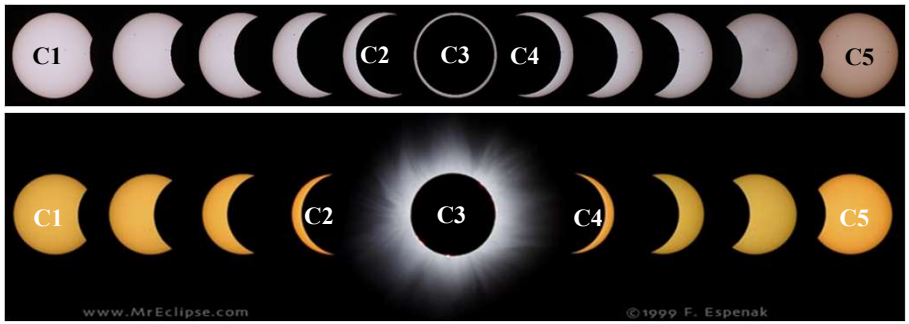
Figure 2 Eclipse path map for the 2024 Total Solar Eclipse [11].

Eclipse Data

Phases of the Eclipse [3]:

1. Partial Eclipse – 1st Contact (C1): The Moon begins to obscure the view of the Sun.
2. Total Eclipse – 2nd Contact (C2): The Moon covers the Sun and the umbra occurs. Observers may be able to see Bailey's Beads and/or the diamond ring.
3. Totality and Maximum Eclipse – 3rd Contact (C3): The Moon completely obstructs the view of the Sun. The midpoint of totality is the maximum of the eclipse.
4. Total Eclipse Ends – 4th Contact (C4): The Moon begins to move away from the Sun and continue its path.
5. Partial Eclipse Ends – 5th Contact (C5): The Moon does not continue to overlap the Sun, the eclipse ends.

Figure 3 and Figure 4 Eclipse time lapses for an annular eclipse and a total solar eclipse [12, 13]



Objectives

The High Altitude Ballooning (HAB) team will have a higher education contact for each eclipse event by the end of the year 2021. Education partners will be within the path of totality and assist St. Catherine University in conducting the research for the 2023 annular and 2024 total solar eclipses. The partners will host the research team and will assist in conducting research vital to conducting investigations into the 2023 and 2024 eclipses.

The instrumentation that will be used to conduct measurements during the 2023 annular and 2024 total solar eclipses will be tested and optimized through five stratospheric balloon flights prior to the end of 2022. The new measurements that will be conducted use silicon photomultipliers (SiPMs) and pressure sensors. The data collected via these new sensors will be improved through the flights prior to the 2023 and 2024 eclipses in order to optimize the eclipse flights.

2023 Annular Eclipse

The San Antonio, Texas area will be used as a launch and landing site for the 2023 annular solar eclipse. It is a relatively flat area and has very good cell tower coverage, which is necessary for communication on balloon launches. San Antonio will be observing Daylight Savings Time during the eclipse which will travel southeast through the western and central parts of the United States. There will be communication with a higher education institute in the San Antonio area and they will become partners for the stratospheric ballooning research. The connection with an institute is necessary to the eclipse investigations because they are able to provide important resources for the team; one of these being the Hydrogen or Helium gas used to fill the balloons. The San Antonio area will provide the accommodations for the team to conduct the research necessary for investigating the 2023 annular solar eclipse.

2024 Total Solar Eclipse

The Indianapolis, Indiana area will be used as a launch and landing site for the 2024 total solar eclipse. It is a relatively flat area and has very good cell tower coverage, which is necessary for communication on balloon launches. Indianapolis will be observing Daylight Savings Time during the eclipse which will travel northeast through the central and eastern parts of the United States. There will be communication with a higher education institute in the Indianapolis area and they will become partners for the stratospheric ballooning research. The connection with an institute is necessary to the eclipse investigations because are able to provide important resources for the team; one of these being the Hydrogen or Helium gas used to fill the balloons. The Indianapolis area will provide the accommodations for the team to conduct the research necessary for investigating the 2024 total solar eclipse.

Common Instrumentation

The measurements conducted by the HAB team will expand upon atmospheric measurements taken in the past, such as temperature measured via wake boom sensors, cosmic ray counts via Geiger–Müller tube, and personal neutron dosimeters (PND), and barometric pressure readings via pressure sensors for investigations during the 2023 annular and 2024 total solar eclipses. New cosmic ray instrumentation will be used via the use of silicon photomultipliers (SiPMs) and pressure sensor measurements during the eclipses. All the instrumentation that will be used during the 2023 and 2024 eclipses will be calibrated and tested by 2023. The HAB team will use new and old instrumentation to take measurements for investigations into the 2023 annular and 2024 total solar eclipses.

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References

[1] Espenak, F., "Glossary of Solar Eclipse Terms," NASA Available: https://eclipse.gsfc.nasa.gov/SEhelp/SEglossary.html. [retrieved 2 July 2020]

[2] "National Eclipse," April 8, 2024 - Total Solar Eclipse Available: https://www.nationaleclipse.com/. [retrieved 17 June 2020]

[3] Hocken, V., and Kher, A., "A Total Solar Eclipse Isn't Total Everywhere," timeanddate.com Available: https://www.timeanddate.com/eclipse/total-solar-eclipse.html. [retrieved 29 June 2020]

[4] Eclipse Predictions by Fred Espenak, www.EclipseWise.com, http://www.eclipsewise.com/solar/SEprime/2001-2100/SE2023Oct14Aprime.html

[5] Eclipse Predictions by Fred Espenak, NASA's GSFC, https://eclipse.gsfc.nasa.gov/SEanimate/SEanimate2001/SE2023Oct14A.GIF

[6] "QR Code Generator," The QR Code Generator Available: https://www.the-qrcode-generator.com/mycodes/uCBPZwD72.

[7] Espenak, F., Eclipse Animation (T99video1w), Lake Hazar, Turkey: nreclipse.com, 2006.

[8] "QR Code Generator," The QR Code Generator Available: https://www.the-qrcode-generator.com/mycodes/ngBzJEE8.

[9] Eclipse Predictions by Fred Espenak, NASA's GSFC, https://eclipse.gsfc.nasa.gov/SEanimate/SEanimate2001/SE2024Apr08T.GIF

[10] "QR Code Generator," The QR Code Generator Available: https://www.the-qrcode-generator.com/mycodes/u8bLZWCHu.

[11] Eclipse Predictions by Fred Espenak, www.EclipseWise.com, http://www.eclipsewise.com/solar/SEprime/2001-2100/SE2024Apr08Tprime.html

[12] BlackDragon72, 2012/05/20 Annular Solar Eclipse Composite, Fallon, Nevada: WordPress.com, 2012.

[13] Espenak, F., Eclipse Sequence - 1 (T99seq1w), Lake Hazar, Turkey: Fred Espenak, 2006.