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# HamSCI Festivals of Eclipse Ionospheric Science: Contesters, HF Operators and SWLs Wanted!

**Ed Efchak WX2R**  
**Public Information Officer**  
**HamSCI**



# Background/My Story

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- **WX2R (formerly WN2AIV then KB2IKI)**
- **Works in strategy planning, media, market research and marketing**
- **A “pretty basic” ham (small station and casual operating)**
- **An “association guy” – I really believe in “groups”**
- **Was PIO, now PIC for ARRL/NNJ**
- **On ARRL Public Relations Committee**
- **Belong to FLARC, FRC, ACARA (VT), West Palm Beach ARG, Chelmsford (UK) ARS**
- **Now Public Information Officer for HamSCI – a strong believer in citizen-science**



# Ham Radio Science Citizen Investigation



HamSCI Booth at the 2023 Dayton Hamvention



Founder/Lead HamSCI Organizer:  
**Dr. Nathaniel A. Frissell, W2NAF**  
*The University of Scranton*

A collective that allows university researchers to collaborate with the amateur radio community in scientific investigations.

## Objectives:

1. **Advance** scientific research and understanding through amateur radio activities.
2. **Encourage** the development of new technologies to support this research.
3. **Provide** educational opportunities for the amateur radio community and the general public.

# Solar Eclipses - Why the Interest?

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- Humankind has always been fascinated by eclipses.
- Fear and ignorance led to many interesting theories of how and why eclipses came about



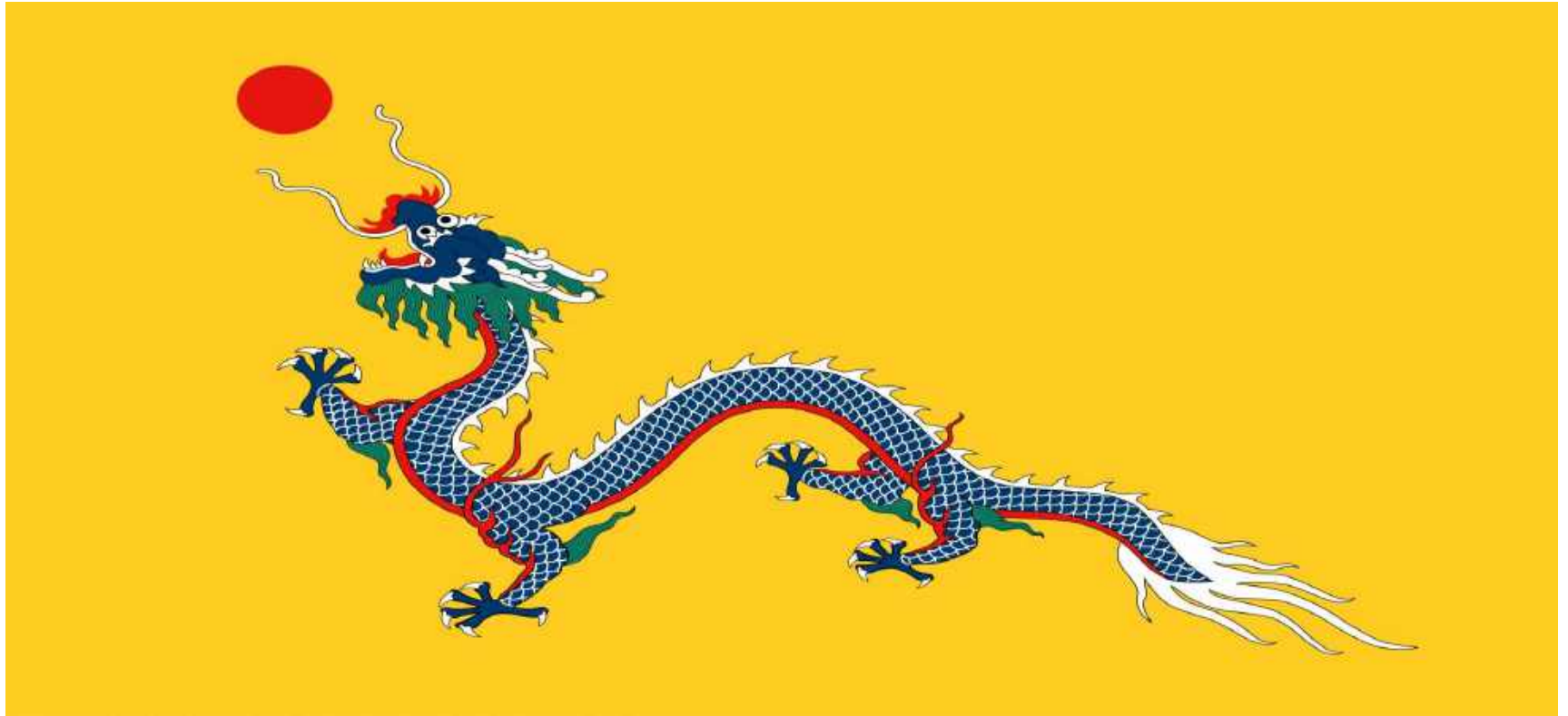
# Thousands of years ago...

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- The ancient Chinese thought that a dragon was eating the sun during an eclipse. They would beat drums and pans to scare the dragon away.
- This was a common theme among the ancients who felt that various groups of animals, including wolves, chased the sun and moon across the sky.
- The animals would occasionally catch and eat the sun or the moon, making them disappear until they regenerated.

# Thousands of years ago...

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# Eclipse Predictions

## Centuries ago:

Astrologers were tasked by the emperors to predict eclipses

If they missed, they could be executed

## Modern Times:

Eclipse predictions are highly accurate - no one's life is at risk!

Accurate predictions allow us to plan studies of eclipse-related phenomena years in advance



[This Photo](#) by Unknown Author is licensed under [CC BY-SA](#)

# North American Solar Eclipses

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## Annular (Oct 2023)



Photo By Smrgeog-commonswiki  
([https://commons.wikimedia.org/wiki/File:Annular\\_Eclipse.\\_Take\\_n\\_from\\_Middlegate,\\_Nevada\\_on\\_May\\_20,\\_2012.jpg](https://commons.wikimedia.org/wiki/File:Annular_Eclipse._Take_n_from_Middlegate,_Nevada_on_May_20,_2012.jpg))

## Total (Apr 2024)



Photo by Jim Sackerman, KC2ZFK



# The Moon Casts a Shadow: Umbra and Penumbra

The Moon passes between the Sun and Earth, creating a shadow with 2 parts:

**Umbra:** innermost region of the shadow; Sun fully hidden & objects in total shadow.

**Penumbra:** outermost region of the shadow; Sun partially hidden & objects still receive some sunlight.

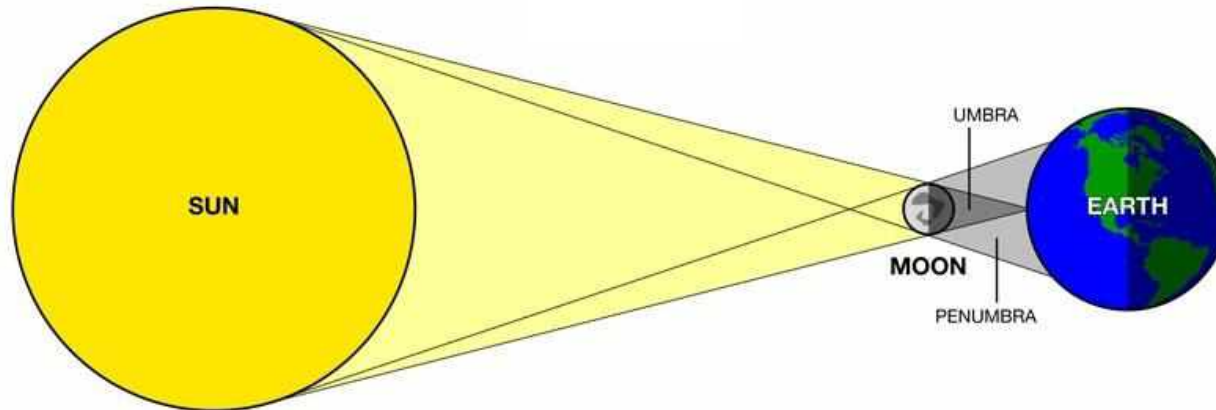


Image: [quora.com/How-do-I-calculate-the-diameter-of-the-shadow-umbra-cast-by-the-Moon-to-the-Earths-surface-during-a-solar-eclipse](http://quora.com/How-do-I-calculate-the-diameter-of-the-shadow-umbra-cast-by-the-Moon-to-the-Earths-surface-during-a-solar-eclipse)

# Total and Annular Solar Eclipses

The distance between the Earth and moon varies during the Moon's orbit

The moon was at apogee (at its furthest from Earth), fitting inside the Solar disk rather than totally obscuring it. This created an **Annular Solar Eclipse in 2023**.

The moon will be at or near perigee (at its closest to Earth) so it will completely cover the solar disk during an eclipse. The result will be a **Total Solar Eclipse in 2024**.

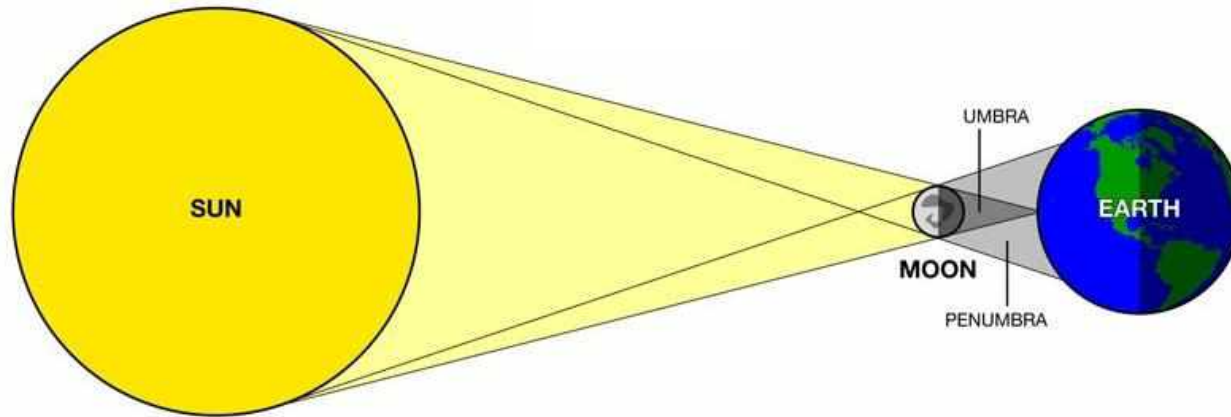
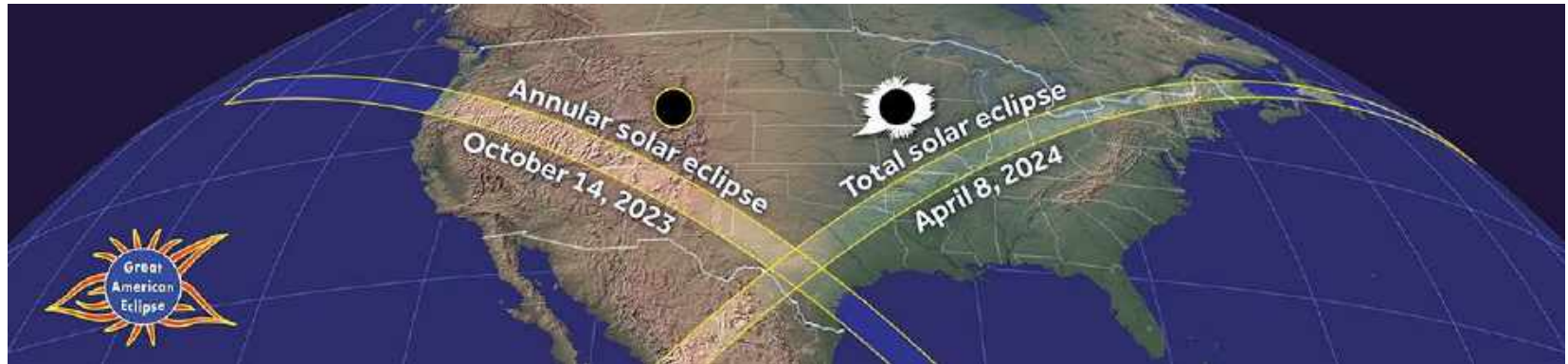


Image: [quora.com/How-do-I-calculate-the-diameter-of-the-shadow-umbra-cast-by-the-Moon-to-the-Earths-surface-during-a-solar-eclipse](https://www.quora.com/How-do-I-calculate-the-diameter-of-the-shadow-umbra-cast-by-the-Moon-to-the-Earths-surface-during-a-solar-eclipse)

# Solar Eclipses - 2023 and 2024

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- HamSCI is beginning to report observations from the 2023 eclipse
- Hams and shortwave enthusiasts are encouraged to join us in 2024



- HamSCI is studying how these two eclipses affect the ionosphere

# The Ionosphere - Layers By Night and By Day

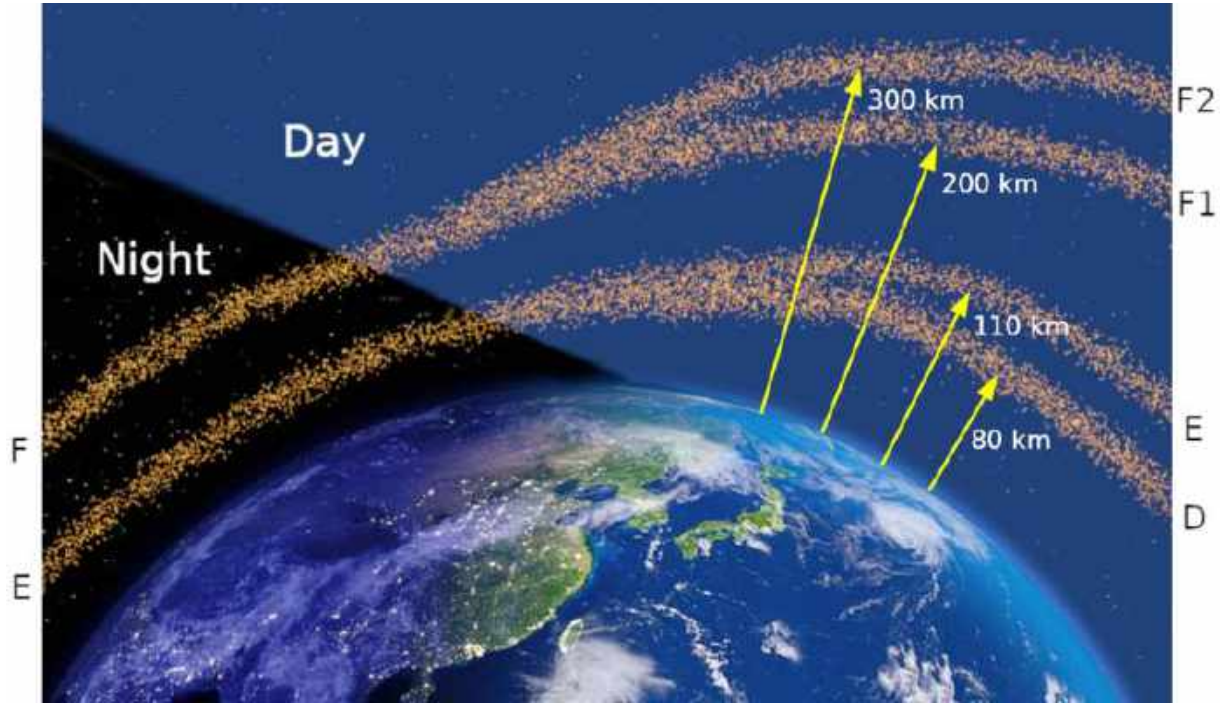


Figure by Carlos Molina ([commons.wikimedia.org](https://commons.wikimedia.org))

# Eclipse Ionospheric Effects

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- After sunrise, but before an eclipse passes overhead, we have 'day' conditions.
- As the eclipse passes overhead, solar radiation is blocked from reaching the ionosphere - briefly simulating 'night' conditions.
- We expect the ionosphere's reaction to be similar to its reaction to the normal, 24-hour night-day cycle.
- But, there are differences...

# Differences Between Eclipses and Day-Night

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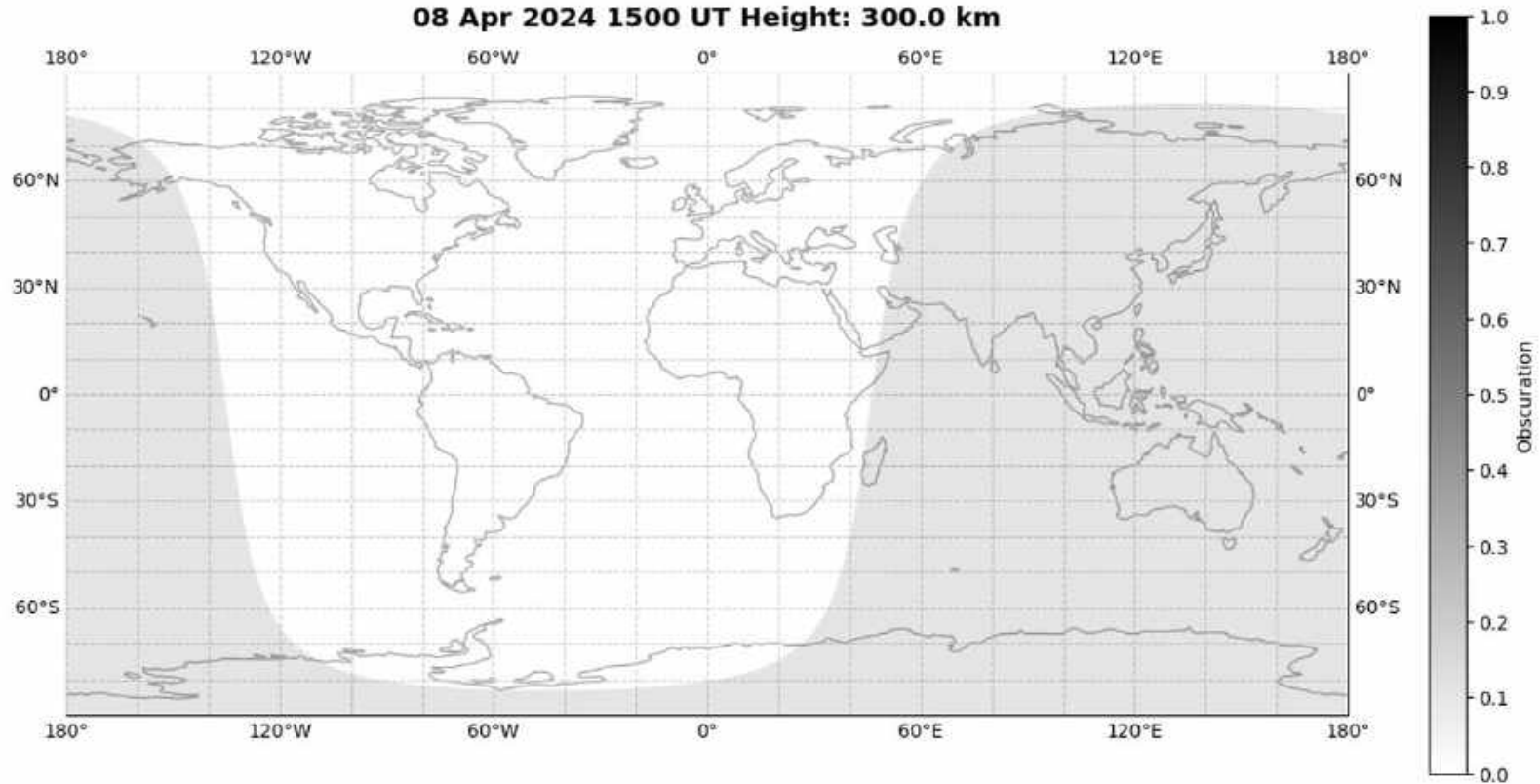
- Eclipse 'night' is of much shorter duration than normal night-time.
- The 'night-time area' is more localized.
- It is caused by an object (the moon) traveling at supersonic speeds.
- It travels in directions that are different from westward motion of normal, daily dawn and dusk terminators.

# Eclipses as Controlled Experiments

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- Aside from dusk, dawn, and the seasons, there are very few cases where we know ahead of time how much solar energy will be input into the upper atmosphere.
- Solar flares, geomagnetic storms, and other space weather events occur randomly; they interfere with day to day observations
- We can, however, calculate eclipses with great accuracy ahead of time, and so they can be considered a “controlled” ionospheric experiments.
- Hams can participate in the experiments, or events, known as the **HamSCI Festivals of Eclipse Ionospheric Science.**

# Total Solar Eclipse: April 8, 2024



Plot generated by Dr. Nathaniel A. Frissell, W2NAF





- The Solar Eclipse QSO Party (SEQP)
- The Gladstone Signal Spotting Challenge (GSSC)
- Build and install a Grape Personal Space Weather Station (PSWS)



- Ionospheric layer height experiment: Time Delay of Arrival Event
- MW (medium wave band) recordings of AM broadcast stations
- VLF enthusiasts: Monitor the 630, 2200 meter and lower bands

# Solar Eclipse QSO Party: The More the Merrier

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- A QSO Party involves hundreds of hams operating the HF bands (6-160 meters) simultaneously - resulting in thousands of QSOs and spots per hour
- It's ham radio's version of a cocktail party - in a really, really big room (potentially the entire Earth)
- CW, SSB and FT4/FT8 QSOs are welcome
- Popular contesting software such as N1MM+ directly supports the SEQP
- Log and spot data will contribute to scientific research on the ionosphere. (Past research results can be found at [hamsci.org](http://hamsci.org), search on '2017 eclipse'.)

# SEQP FAQs and Rules

- 6-160 meters (non-WARC bands) using CW, SSB and digital modes like FT8
- The HamSCI website is the ultimate resource:
  - <https://hamsci.org/contest-info>
  - <https://hamsci.org/seqp-faqs>
  - <https://hamsci.org/seqp-rules>
- Certificates for all participants
- Results will be published

HamSCI

## Solar Eclipse QSO Party Rules for 2023 and 2024

Please bookmark this page and join the **HamSCI eclipse mailing list** for future announcements related to the SEQP.

Version 1.01

3 Dec 2022

The following are the complete, detailed rules for the SEQP. For a quick introduction to the SEQP, please visit the **SEQP FAQ** page. The SEQP is one event within the **Festivals of Eclipse Ionospheric Science**.

### I) Dates and Times

14 Oct 2023 1200 – 2200 UTC (Partial eclipse begins ~1500 UTC in Oregon ends ~1840 UTC in Texas)

8 Apr 2024 1400-2400 UTC (Partial eclipse begins ~1710 UTC in Texas and ends ~2040 UTC in Maine)

*Participants are encouraged to operate before, during and after the eclipse passes over the continental US. Doing so will create baseline data (pre- and post-eclipse), and eclipse influenced data (during annularity or totality) for the research team.*

### II) Objective

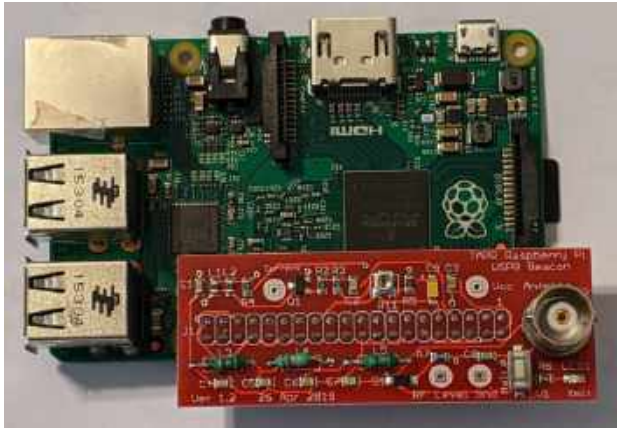
To generate observations of propagation by the **Reverse Beacon Network** and **PSKReporter** event logs before, during, and after the eclipse on the amateur bands for the purpose of ionospheric sounding.

The Solar Eclipse QSO Party (SEQP) is unique among ham radio competitions as it awards points for two-way QSOs (ham to ham contacts via radio) and bonus points for reception reports from skimmers, RBN nodes and the like.

# Gladstone Signal Spotting Challenge

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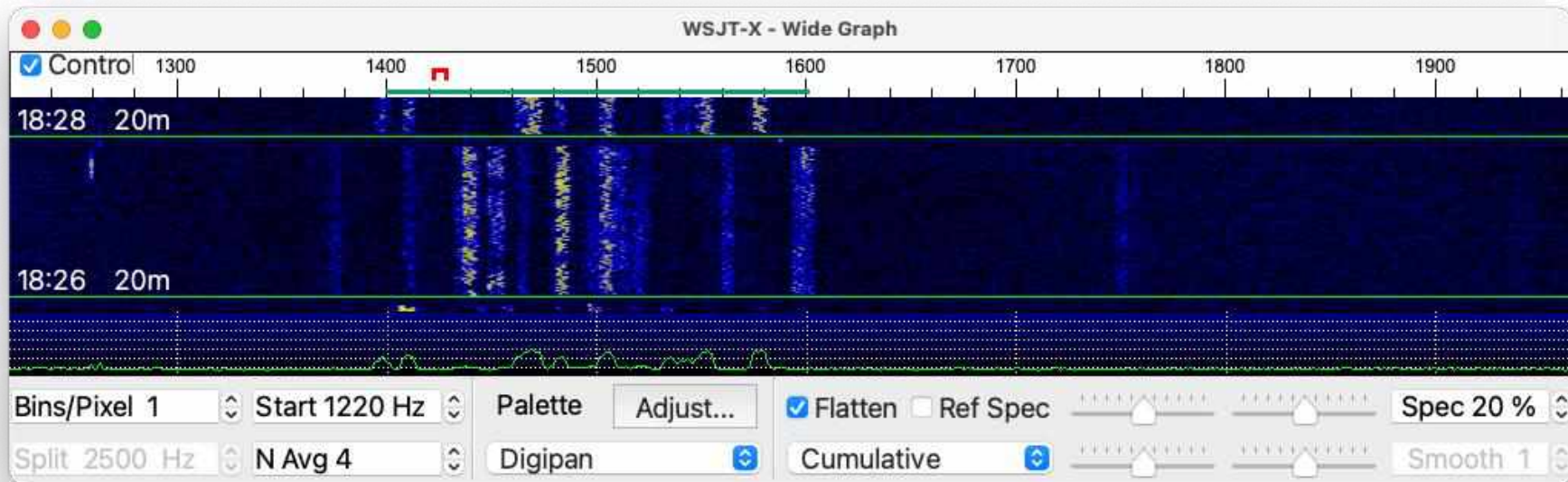
- The GSSC is for those who transmit and/or receive WSPR (**W**eak **S**ignal **P**ropagation **R**eporter, c. 2010) or FST4W.
- WSPR is a mode commonly used for propagation studies. Its data lends itself to ‘big data analytics’ and visualization. FST4W is a similar, but higher performance mode.
- Equipment needs are very simple - racks full of gear are definitely *not* required!



Simple Raspberry Pi based WSPR Transmitter, courtesy <https://tapr.org>

# Gladstone Signal Spotting Challenge

- Should appeal to those already interested in radio wave propagation
- Learn more at [WSPR.live](http://WSPR.live) or [WSPRdaemon.org](http://WSPRdaemon.org)



# Gladstone Signal Spotting Challenge

- The HamSCI website has details on the Challenge and links to WSPR and FST4W information
- <https://hamsci.org/contest-info>
- <https://hamsci.org/gssc-faqs>
- <https://hamsci.org/gssc-rules>
- The 2023 results have been published at <https://hamsci.org/foeis-results>



The screenshot shows the HamSCI website page for the Gladstone Signal Spotting Challenge. The page header includes the HamSCI logo. The main title is "Gladstone Signal Spotting Challenge Rules for 2023 and 2024". Below the title is a yellow callout box with the text: "Please bookmark this page and join the HamSCI eclipse mailing list for future announcements related to the GSSC." The page also includes a version number "Version 1.22" and a date "24 Jan 2023". A paragraph of text describes the challenge's namesake, Phil Gladstone (N1DQ), and his work with PSKReporter.info. It mentions that the challenge is named for him and that he has made a significant contribution to amateur radio operating, citizen-science, and ionospheric research. A link to a Wikipedia entry is provided: [https://en.wikipedia.org/wiki/PSK\\_Reporter](https://en.wikipedia.org/wiki/PSK_Reporter). Below this, there is a section titled "I) Dates and Times" which lists two events: "14 Oct 2023 1200 - 2300 UTC (Partial eclipse begins ~1500 UTC in Oregon and ends ~1840 UTC in Texas)" and "8 Apr 2024 1400-2400 UTC (Partial eclipse begins ~1710 UTC in Texas and ends ~2040 UTC in Maine)". A note encourages participants to operate before, during, and after the eclipse to create baseline data and eclipse-influenced data. The next section is titled "II) Objective" and states that the goal is to generate observations of propagation by WSPRNet, PSKReporter, and the Reverse Beacon Network, along with participants' event logs before, during, and after the eclipse on the amateur bands for the purpose of ionospheric sounding.

# Grape Personal Space Weather Stations

The HamSCI PSWS Project is placing low-cost SDRs in dozens of locations all across the Americas.

The Grape PSWS serves a very specific purpose: Recording changes in the Earth's ionosphere through measurements of Doppler frequency shifts observed by monitoring, on a 24/7 basis, frequency standard stations such as [WWV/H](#) and [CHU](#).



Grape PSWS receiver/mixer board

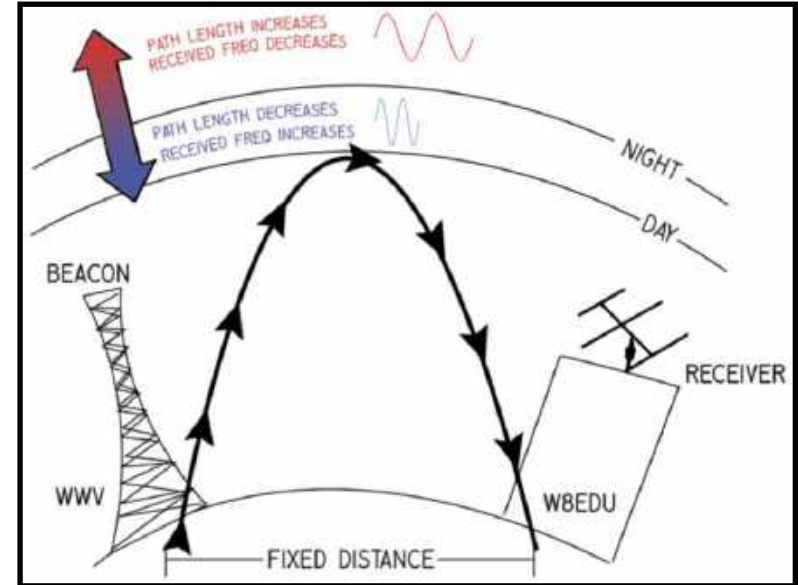
0.88 x 1.56 inches



# Grape PSWS - For More Information

A full explanation of the science behind the Grape PSWS, and the ways that the Grape system components achieve the scientific goals, are beyond the scope of this talk.

In the simplest of terms, the Sun greatly affects the ionosphere. We can sense the bottomsides of the ionosphere by measuring the received frequency of stations such as WWV to milliHertz precision.

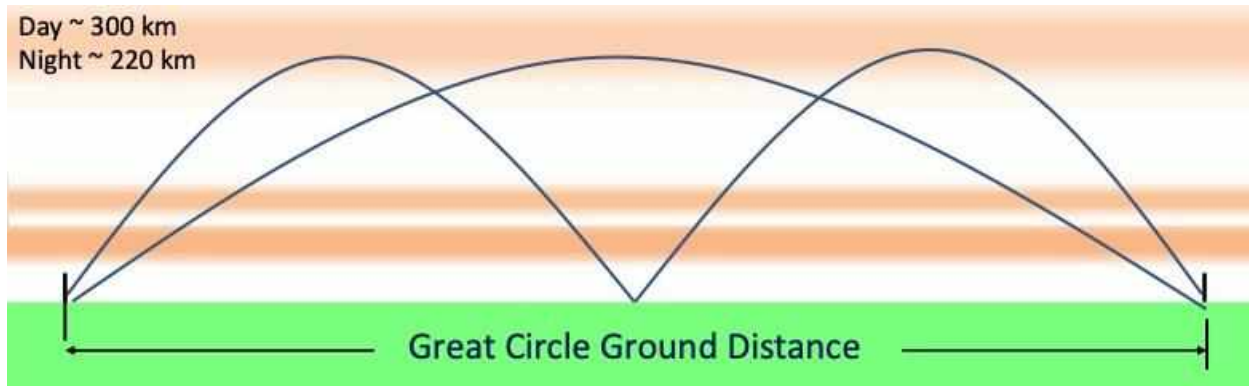


Full details on how to build, how to participate and the science behind the PSWS, visit <https://hamsci.org/grape>

Image: C. Collins, KD8OXT

# Time Delay of Arrival Event

- For the science minded amateur who would like to be part of a controlled experiment
- Transmit/receive a 'chirp signal', custom generated for your station/callsign, during the eclipses
- Measure changes in the observed F2 layer height as the solar eclipse impacts the ionosphere



- The HamSCI website has all of the details, including a sign-up form
- <https://hamsci.org/tdoa-event-2023>

Image: S. Cerwin, WA5FRF

# In Summary: FoEIS is Fun, with a Purpose

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**What's in it for hams? Long term benefits of participation:**

- Improved understanding of HF propagation
- Improved models of the ionosphere
- More accurate propagation forecasts

**Now is a good time to ask: What did we learn from the October eclipse?**



# Interesting Observations from the October 14, 2023 Eclipse

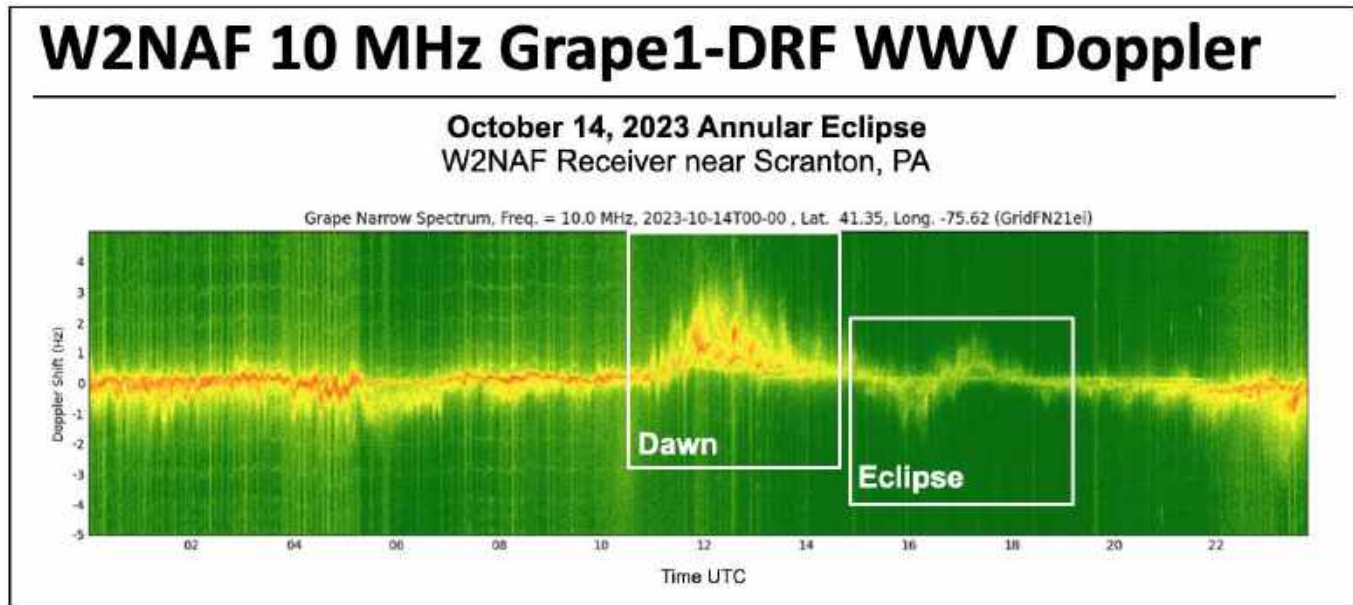
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We are prepared to discuss Observations, but not Findings

- Observations: What we saw
- Findings: Why we saw it
- Data analysis, developing and testing theories takes time
- Preparation of articles and papers involves the peer review process - fundamental to science, but lengthy (years long)
- Expect findings in late 2024, 2025 and beyond

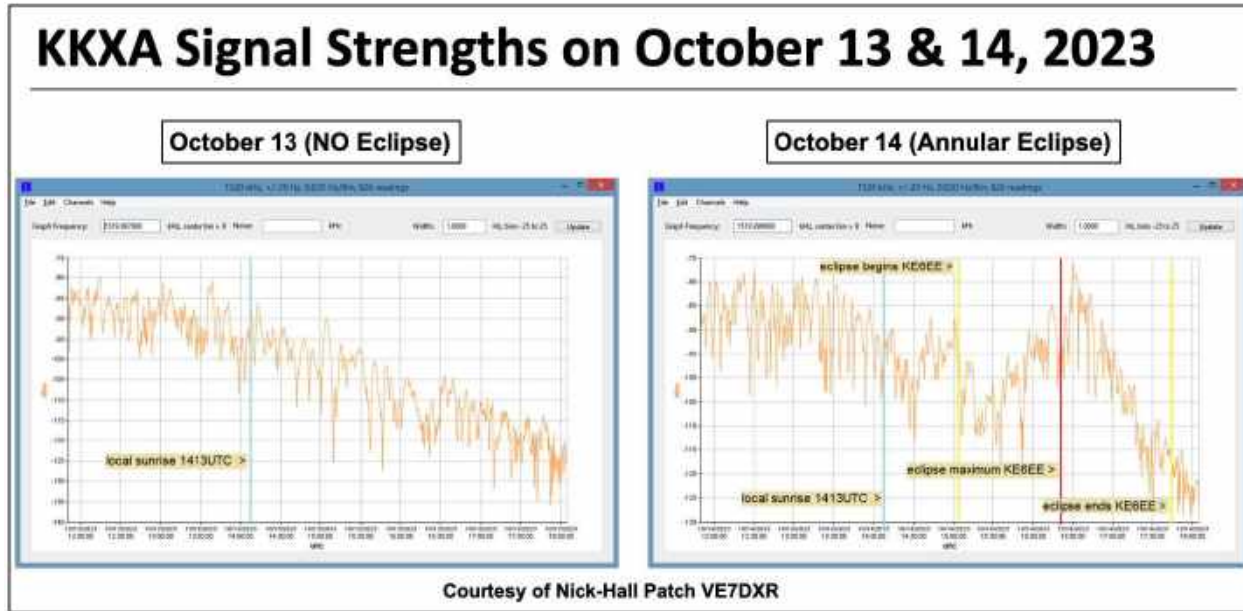
# Grape Receiver Observation

Here is evidence that the ionosphere's eclipse reaction is similar to its dawn reaction - important for validating the receive system



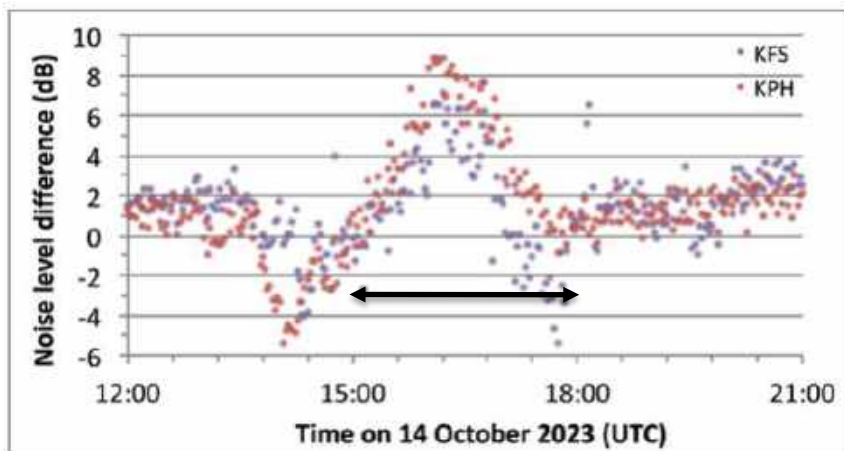
# Medium Wave Reception Observation

These graphs demonstrate the value of control data: Signals received one day prior to the eclipse vs. enhancement during the eclipse event

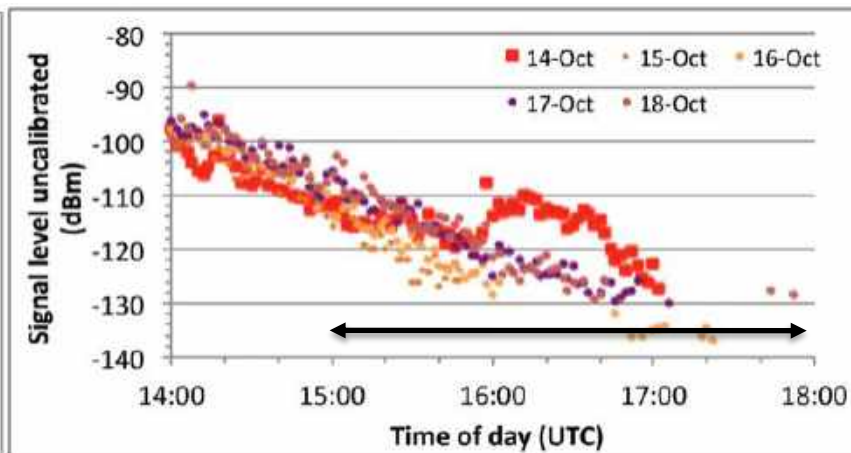


# Noise and Signal Level Enhancements

Careful graphing of received signals levels using the FST4W mode show noise levels peaking (left) and signal levels peaking (right) during the eclipse



7.040 MHz noise anomaly, the difference between noise on 14 October and the average at the same time over the previous five days for KFS and KPH



Signal levels on 14-18 October 2023 at KA7OEI-1 for FST4W transmissions from WO7I on 3.57 MHz.

# Participation is Key - The More, the Better

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## Interested in Participating?

- Follow [HamSCI.org/eclipse](http://HamSCI.org/eclipse) and join <https://groups.google.com/g/hamsci-eclipse>
- Pre-register for the events at [HamSCI.org/eclipse](http://HamSCI.org/eclipse)
- *Operate in the SEQP or GSSC*
- *Join the TDOA Event*
- *Put your MF or VLF monitoring skills to work*
- *Build a Grape receiver*



# HamSCI Zoom Telecons—Get Involved!!

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## TangerineSDR Telecon



Engineering telecon to support the TangerineSDR and magnetometer board development.

Mondays at 9 PM Eastern  
(Tuesdays 0200z)

Telecon to support engineering and science related to the Grape (low-cost) Personal Space Weather Station.

Thursdays at 10 AM Eastern  
(1500z)

Telecon to support the 2023 and 2024 Solar Eclipse QSO Parties.

Thursdays at 4 PM Eastern  
(2100z)



# HamSCI Zoom Telecons—Get Involved!!

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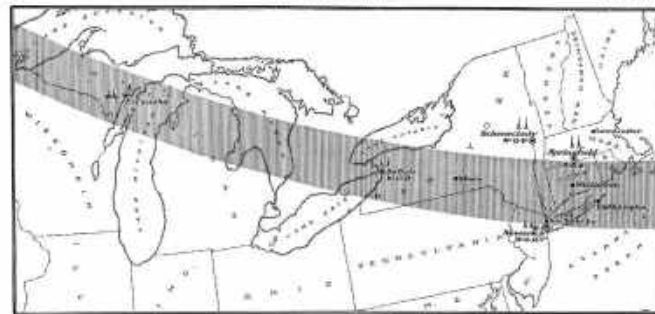
- **March 22-23, 2024 @**  
Case Western Reserve University  
Cleveland, OH
- Theme will be **Alignments**  
between
  - the Sun, Moon and Earth
  - collegiate amateur radio recreation  
and STEM curriculum
  - data collection and analysis
  - professional and citizen science.

**Join us in person or online!**

**<https://hamsci.org/hamsci2024>**



## Citizen – Science Comes Full Circle in 100 Years



TRANSMITTING AND RECEIVING STATIONS WERE LOCATED AS SHOWN ON THIS MAP

### The Effects of the Eclipse on Radio

A Preliminary Report of the Comprehensive Observations Made By Our Own Collaborators and Others

By Alfred P. Lane and F. N. Washburn  
of the Scientific American Eclipse Party

The eclipse was unquestionably the greatest experiment ever made in radio science. It was a great success. It will be months before we can analyze all of the data and decide upon the conclusions which are to be set down in detail. The bulk of every cooperating engineer is piled high with thousands of reports from the following sources and from the laboratories, broadcasting stations and individual operators who conducted their own investigations. To dig up all the data which have been so kindly deposited, and to work up all the data we have had, at this writing, into these condensed two columns of readily used and used.

#### Something in All Affects Radio

Nevertheless, it is possible to say already that the facts obtained will be of the utmost importance to the doctors of radio transmission, and possibly to the practice of radio as well. We have always assumed that the sun affects radio, now we know that it does. We have had a rather interesting belief in some sort of an indirect layer high up in the sun's atmosphere—the so-called Hertzian Layer. Now we know that something in the upper air really does affect the progress of the radio waves.

This sounding story will be exactly what we have needed at the Hertzian Layer. That there may need modification, but we have obtained, it is probable, the data which will enable us to make these modifications, to formulate new theories which are true to the truth.

The radio investigators attempted during the eclipse to do, more or less directly, two things: First, a number of radio engineers, headed by Mr. Gustaf W. Fickler, organized a network of trans-

mitted receiving stations at Miami, New York; Lancaster (about sixty miles west of Boston), Massachusetts; Middletown, Connecticut; and New York City. The last named station was at the laboratory of the Radio Corporation of America, in charge of Mr. Alfred N. Goldsmith.

At each of these stations a receiving record was made showing, instant by instant, the actual field strength of each wave of the broadcasting station (WJZ, WJZL, WJZK and WJZL). At New York City a record was made also of the reception from WJZ, the shortwave station of the General Electric Company at Schenectady, New York. These records ran several hours before and after locality. Comparative records were made in preceding and following days.

In addition to this network, instrumental records of one or more broadcasting stations were made at the Bureau of Standards, Washington, D. C.; at the laboratories of the General Electric Company, Schenectady; by Mr. David Curran, at Waltham, Connecticut; by Mr. Albert Herring at Newport, Rhode Island; by Professor Howard M. Fry of Johns University, Baltimore, Pennsylvania; by the laboratories of E. A. H. Sadler, Inc., in New York City; by Mr. Joseph E. Howell, in Brooklyn, New York; by the Scientific American Co. (on the local level) and by others.

The second group of observations included the tests made by the radio engineers, using waves within the regular broadcast band. Twenty amateur wave radio sets were on the ether and many other amateurs were told of the time in case of some of these transmitting stations and to record any changes in locality. These tests were organized by the American Radio Relay League.

The third part of the radio work was that which the Scientific American was especially concerned, the organization of tests by the radio amateurs who volunteered to help. More than two thousand such amateurs registered with us or with one or the other of the co-operating broadcasting stations. The majority of these amateurs have sent us reports. In addition, we have received reports from several hundred persons who failed to hear of the time in their own reports but who learned of the progress of the eclipse and made records in all of these conditions. They have been in a class of great value. We hope that the knowledge of a good job well done will prove to them a satisfactory reward in their effort and time.

#### Stations Transmitted Special Copy

We are grateful, too, to the last broadcasting station which assisted, in all length and comprehensiveness, in our tests. These were WJZL, the Federal Telephone Manufacturing Company, in Rahway, New York; WJZL, the National Electric Company, Schenectady, New York; WJZ, the Washington Electric and Manufacturing Company, Springfield, Massachusetts; and WJZL, L. R. H. Company, New York, New Jersey. At each of these stations a special eclipse program was transmitted beginning at 10:10 a. m. Eastern Standard Time, on the morning of the eclipse. At 10:15 a. m. each station began sending special copy, each word of which was carefully typed in the transmitting station, so that it was known the exact second at which each spoken word went out on the ether.

The cooperating stations had been checked previously, each group, with groups mentioned in time to

# Publications

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HamSCI research has been presented and published in many different forums, from general interest magazines to peer-reviewed papers, conferences, workshops, websites and PhD dissertations. Examples include:

- American Geophysical Union Publications:
  - Space Weather
  - Geophysical Research Letters
  - Journal of Geophysical Research: Space Physics
- Frontiers in Astronomy and Space Sciences
- Institute of Electrical and Electronic Engineers' Geoscience and Remote Sensing Letters
- Institute of Electrical and Electronic Engineers' Transactions on Antennas and Propagation
- CQ, Amateur Radio Communications & Technology (CQ Communications, Inc.)
- QEX, A Forum for Communications Experimenters (American Radio Relay League)
- QST (American Radio Relay League)

# Acknowledgments

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We are especially grateful for the

- support of NSF Grants AGS-2002278, AGS-1932997, AGS-1932972, AGS-2045755, AGS-2230345, and AGS-2230346.
- support of the NASA SWO2R Grant 80NSSC21K1772.
- support of Amateur Radio Digital Communication (ARDC).
- amateur radio community volunteers who have contributed to HamSCI projects.
- amateur radio community who voluntarily produced and provided the HF radio observations mentioned here, especially the operators of the Reverse Beacon Network (RBN, [reversebeacon.net](http://reversebeacon.net)), the Weak Signal Propagation Reporting Network (WSPRNet, [wsprnet.org](http://wsprnet.org)), PSKReporter ([pskreporter.info](http://pskreporter.info)) [qrz.com](http://qrz.com), and [hamcall.net](http://hamcall.net).
- use of the Free Open Source Software projects used in this analysis: Ubuntu Linux, python (van Rossum, 1995), matplotlib (Hunter, 2007), NumPy (Oliphant, 2007), SciPy (Jones et al., 2001), pandas (McKinney, 2010), xarray (Hoyer & Hamman, 2017), iPython (Pérez & Granger, 2007), and others (e.g., Millman & Aivazis, 2011).

# Questions?

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# Thank You!!

# Keep In Touch!



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