HamSCI Festivals of Eclipse Ionospheric Science Looking for: Contesters, HF Operators and SWL's

Bill Mader, K8TE, ARRL Section Manager, New Mexico

2023 Rocky Mountain Division Convention

K8TE Background

- Licensed as WV2RBF Feb 1960 now a Contester & DXr
- Science NERD with Astronomy Focus 1976-78 in MI
- 2017 Total Solar Eclipse in Lander WY

Band	Mode	QSOs	Pts
7	CW	8	16
7	LSB	1	1
14	CW	217	434
14	USB	18	18
Total	Both	244	469

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

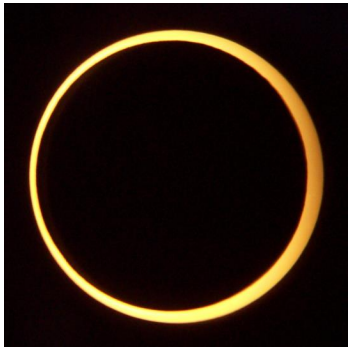
University Researchers Collaborating with the Amateur Radio Community in Scientific Investigations

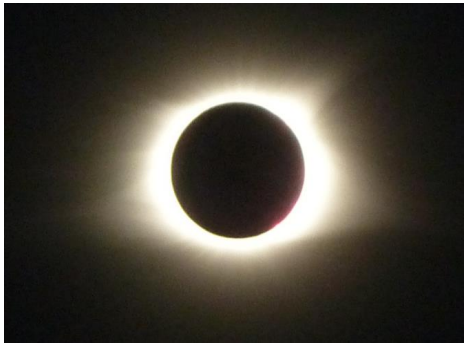
Objectives:

1. **Advance** Scientific Research and Understanding through Amateur Radio Activities
2. **Encourage** Development of New Technologies to Support this Research
3. **Provide** Educational Opportunities for the Amateur Radio Community & the General Public

Solar Eclipses - Why the Interest?

- Humankind Always Been Fascinated by Eclipses
- Fear and Ignorance Explain Many Interesting Theories of How and Why Eclipses Occur

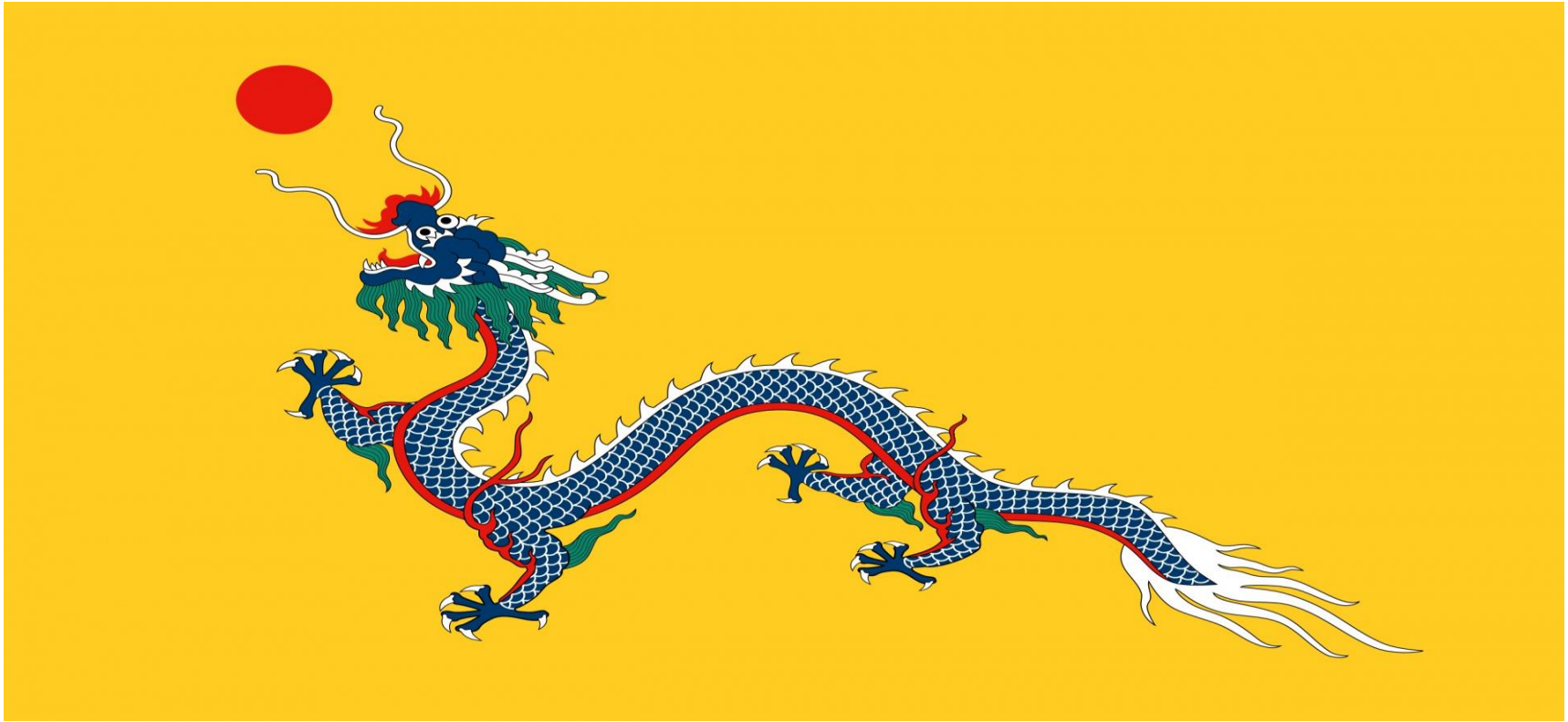




Thousands of years ago…

- Ancient Chinese: a Dragon Was Eating the Sun
  They Beat Drums and Pans to Scare the Dragon Away
- Ancients Felt Groups of Animals Including Wolves
  Chased the Sun and Moon Across the Sky
- These Animals Occasionally Caught and Ate the Sun or Moon
  Making Them Disappear Until They Regenerated

Thousands of years ago…



Eclipse Predictions

Centuries ago:

Emperors Tasked Astrologers
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 Planning
Eclipse Studies of Related Phenomena
Years in Advance

Upcoming Solar Eclipses

Annular (2023)

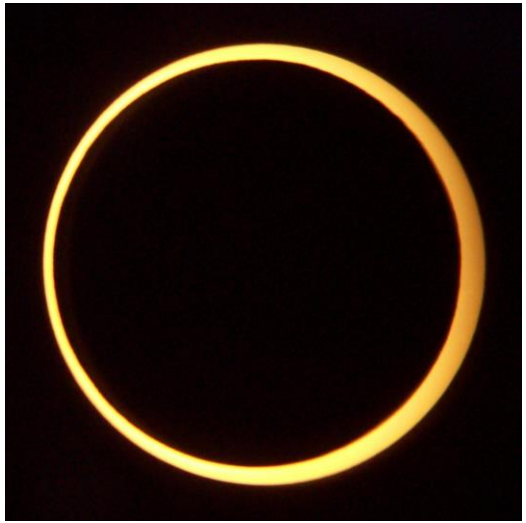


Photo By Smrgeog~commonswiki (https://commons.wikimedia.org/wiki/File:Annular_Eclipse._Taken_from_Middlegate,_Nevada_on_May_20,_2012.jpg)

Total (2024)

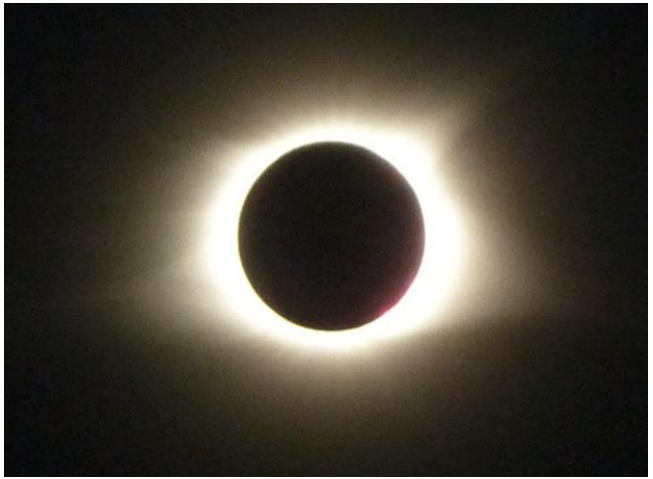


Photo by Jim Sackerman, KC2ZFK

Umbra and Penumbra

Moon's Shadow has 2 Parts

- **Umbra: Innermost** Region: Sun **Fully** Hidden & Objects in Total Shadow
- **Penumbra: Outermost** Region: Sun **Partially** Hidden with Some Sunlight

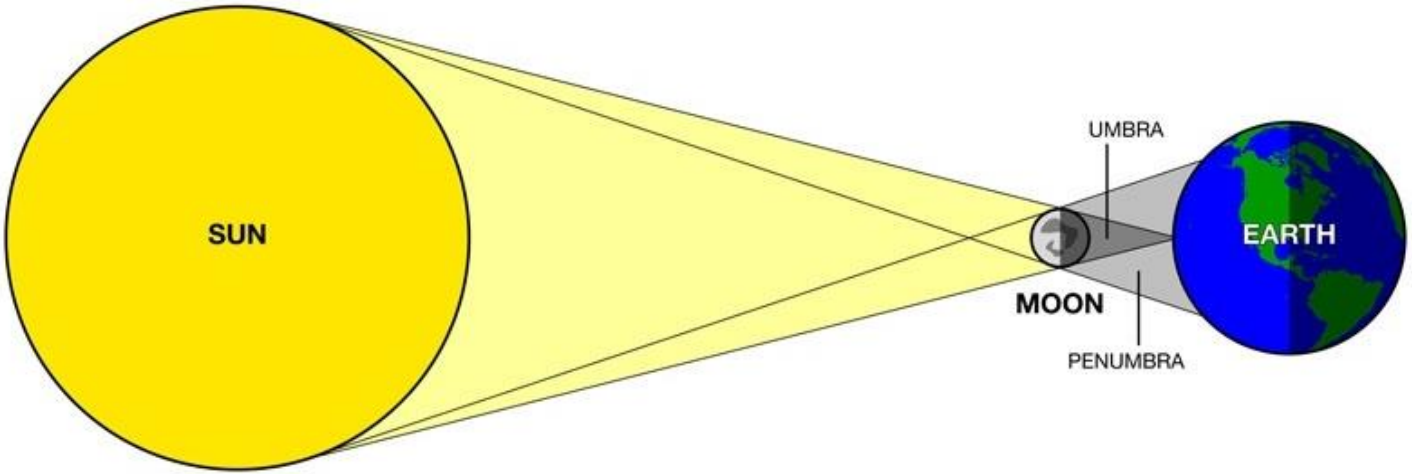


Image: quora.com/How-do-I-calculate-the-diameter-of-the-shadow-umbra-cast-by-the-Moon-to-the-Earths-surface-during-a-solar-eclipse

Total and Annular Solar Eclipses

- Distance Between the Earth and Moon Varies During the Moon's Orbit
- The Moon at Apogee (Farthest from Earth) fits Inside the Solar Disk
  This Results in an **Annular Solar Eclipse (14 Oct 2023)**
- The Moon At/Near Perigee (Closest to Earth) Completely Covers the Solar Disk
  This results in a **Total Solar Eclipse (8 Apr 2024)**

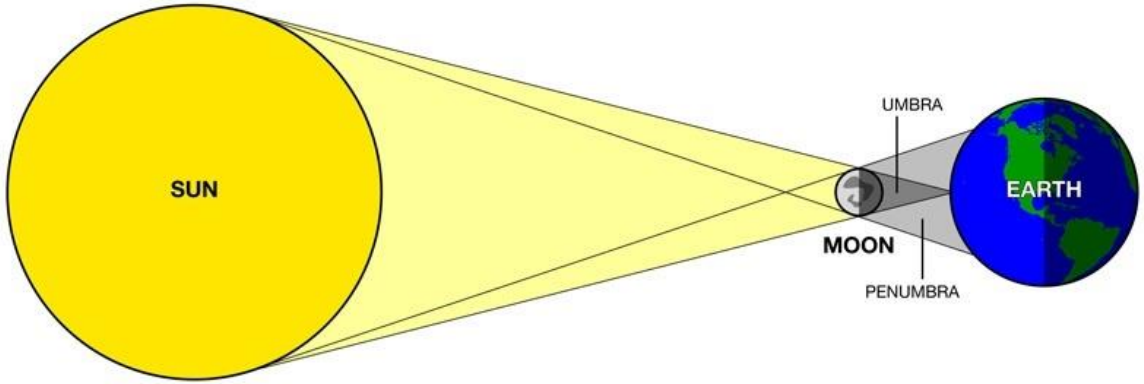
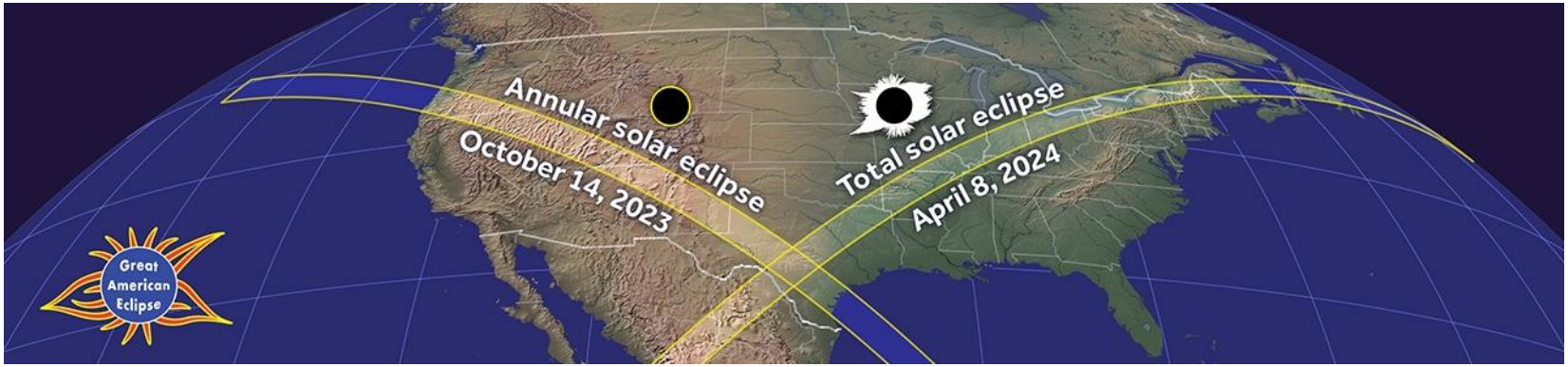


Image: quora.com/How-do-I-calculate-the-diameter-of-the-shadow-umbra-cast-by-the-Moon-to-the-Earths-surface-during-a-solar-eclipse

Solar Eclipses - 2023 and 2024

- HamSCI Planning a Full Slate of Events
- Hams and Shortwave Enthusiasts Encouraged to Join the Fun!



- HamSCI is Promoting the **Festivals of Eclipse Ionospheric Science**

Main Area of Study: The Ionosphere

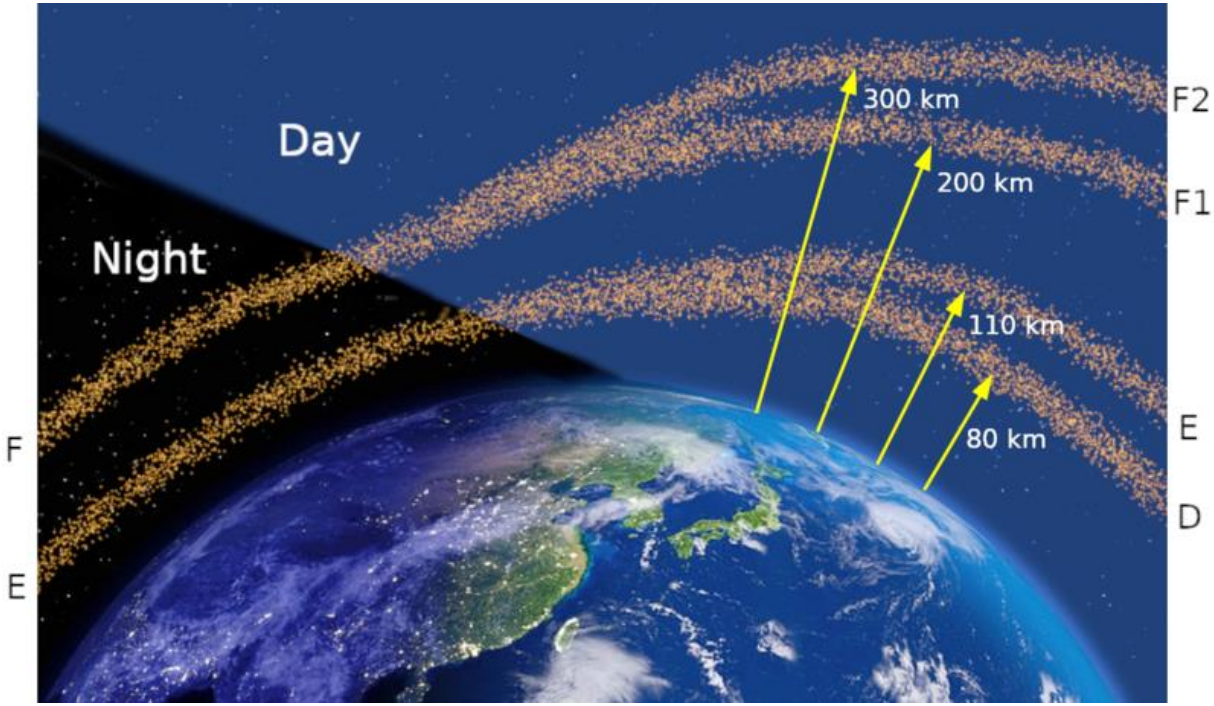


Figure by Carlos Molina (commons.wikimedia.org)

Eclipse Ionospheric Effects

- Solar radiation is blocked During an Eclipse
- the Ionosphere's reaction is Similar to the 24-hour Day-Night Cycle
- But, There Are Differences…

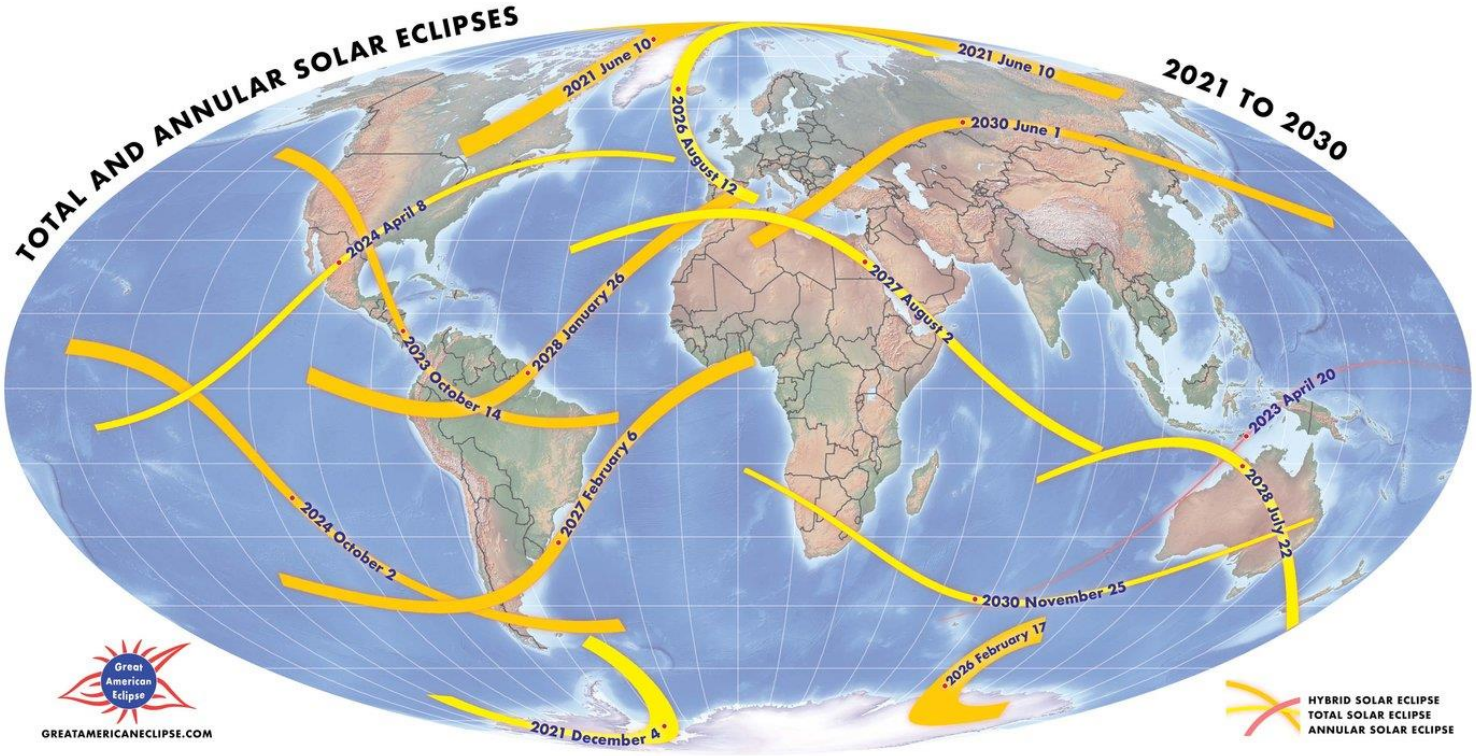
Differences Between Eclipses and Day-Night

- Eclipse is Shorter in Duration
- The Effects are More Localized
- The Shadow Travels at Supersonic Speeds
- Travel is Different from Westward motion of Dawn and Dusk

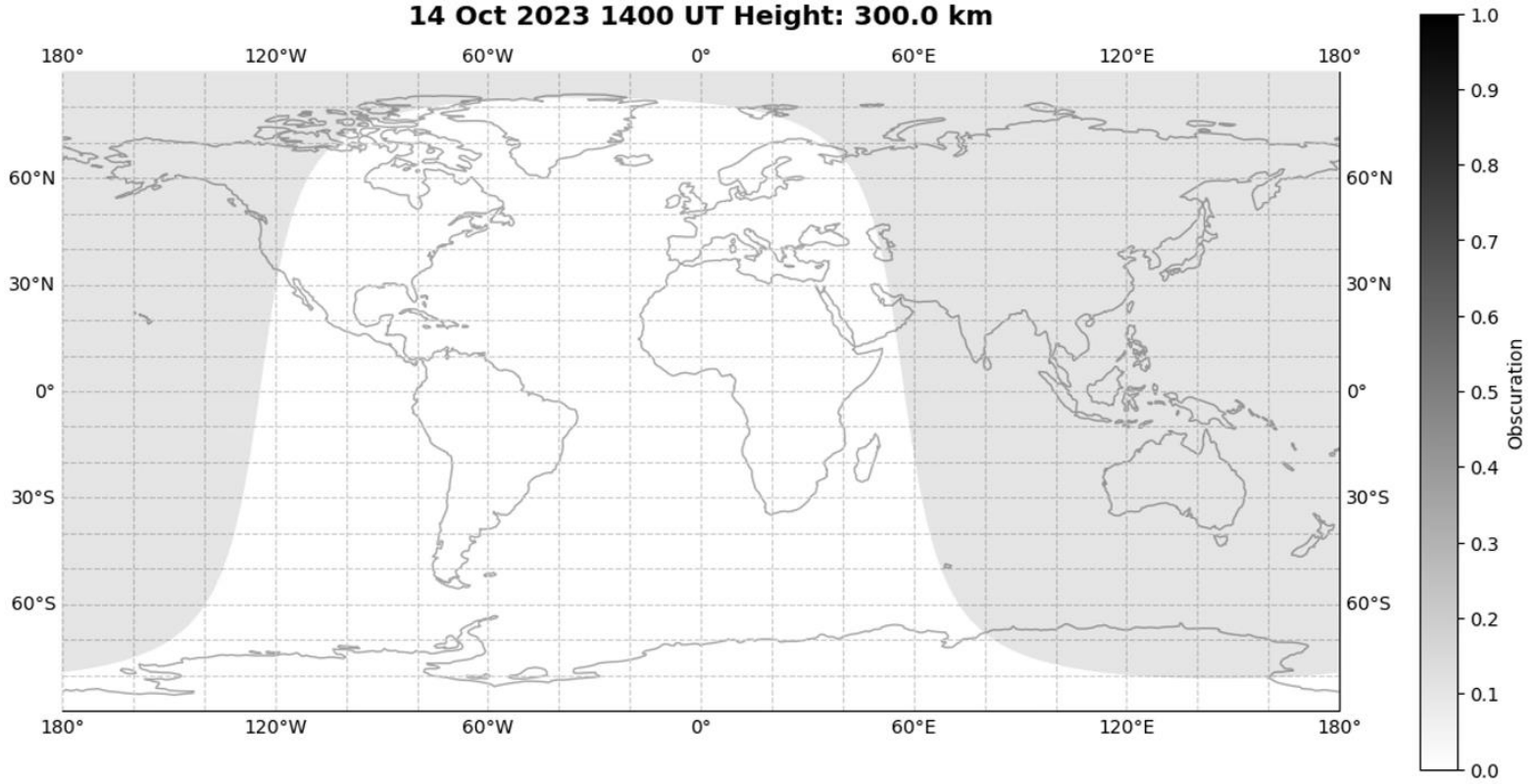
Eclipses as Controlled Experiments

- We Know & **Can** Predict Solar Energy Input
  to the Upper Atmosphere from Dusk, Dawn, and the Seasons
- We **Cannot** Predict Energy from
  Solar flares, Geomagnetic Storms, or Other Random Events
- We Know Eclipses' with Great Accuracy
  Thus, They're Considered "Controlled" Ionospheric Experiments

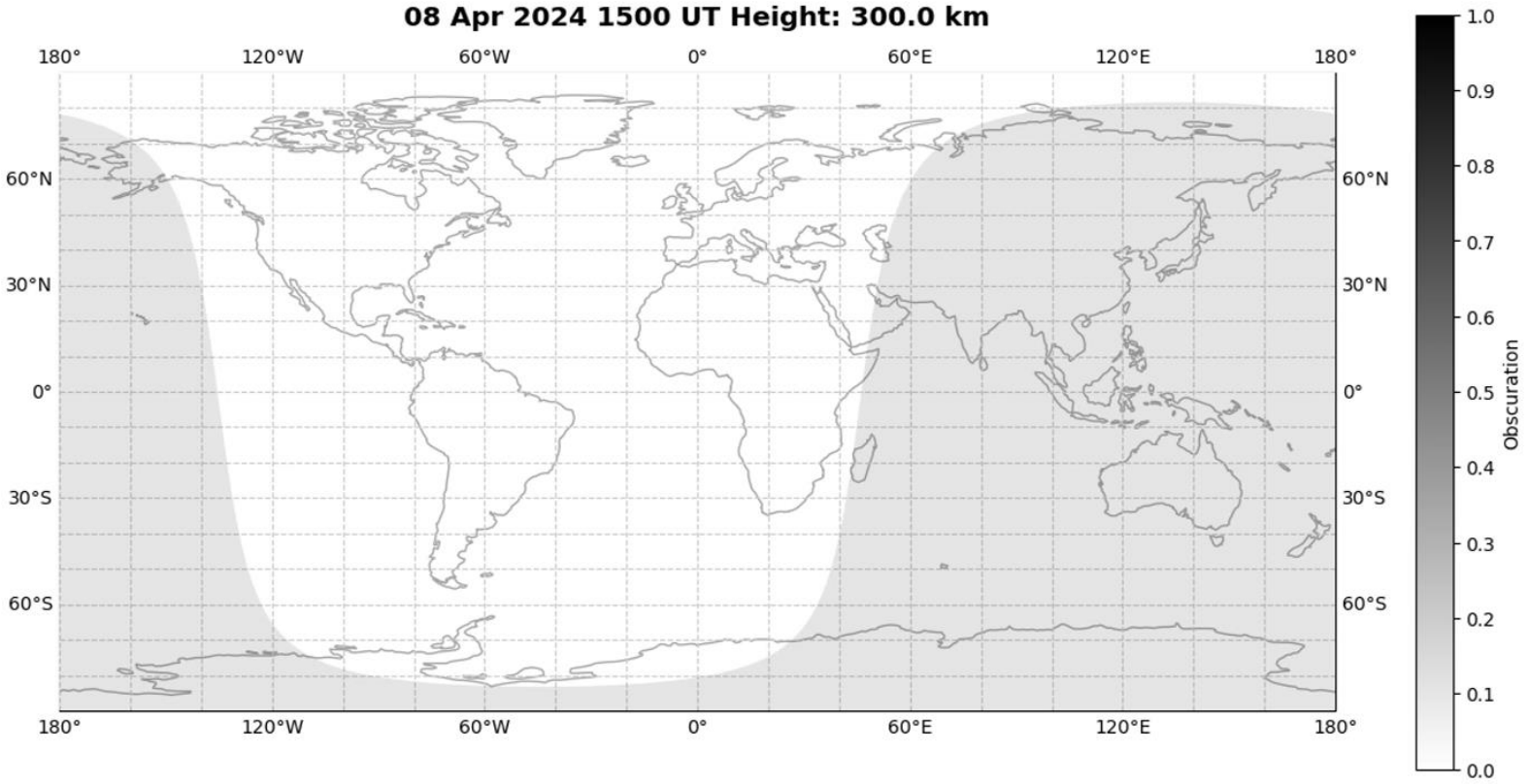
Next Decade of Eclipses



Annular Solar Eclipse: October 14, 2023



Total Solar Eclipse: April 8, 2024



Plot generated by Dr. Nathaniel A. Frissell, W2NAF

- Ham Radio Competitions:
  Solar Eclipse QSO Party and Gladstone Signal Spotting Challenge
- Participate in a controlled experiment on the 160, 75 or 40 meter bands:
  Time Delay of Arrival (TDOA) Event
- Build and install a Grape Personal Space Weather Station (PSWS)

QSO Party: The More the Merrier

- Hundreds of Hams Operating Simultaneously
  Results in Thousands of QSO's and Spots Per Hour
- Ham Radio's Version of a Really, Really Big Room (Potentially the Entire Earth)
- HamSCI Organized the 2017 Solar Eclipse QSO Party (SEQP)
  A Total Eclipse Transited the North American Continent
- The 2017 SEQP Had a Scientific Purpose:
  Data Generation and Collection for Ionospheric Science
- Logs and Spots Data Contributed Directly to Scientific Ionospheric Research
- Research Available at hamsci.org
  Search on "2017 Eclipse"

2017 Solar Eclipse QSO Party Results

Participant's Log Data

Submitted Logs	566
Log QSOs	29,809
Log Unique Calls	4,929
Log 4-Character Grid Squares	649
Log DX Entities	80

Spotting Network Data

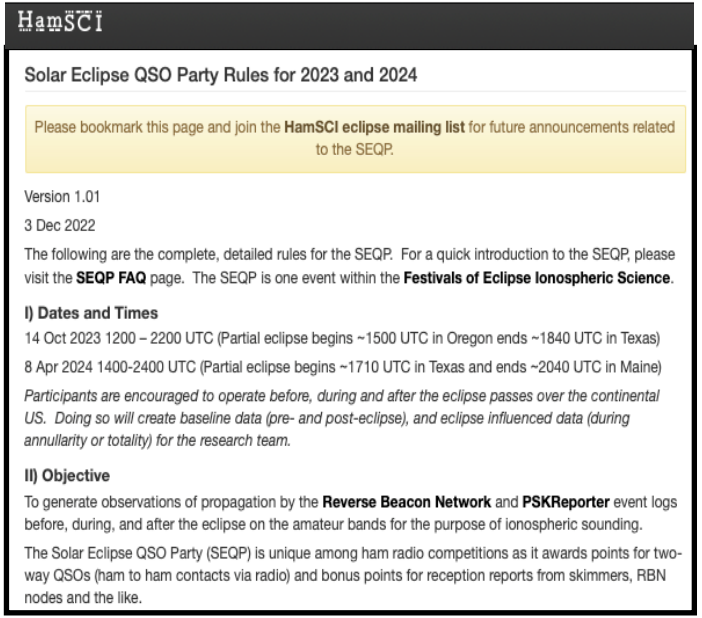
RBN Spots	618,623
WSPRNet Spots	630,132
PSK Reporter Spots	1,287,962

'Spot' Single Station's Transmission
Automated Reception Report
Entered Into a Database

Create a Computer **Log** of All QSOs
Submit **Your** Log to HamSCI
After the Event

Solar Eclipse QSO Party 2.0

- Using the Best Concepts from 2017 Yielded a Fresh Set of Rules, FAQs, etc.
- 6-160 meters (Non-WARC bands) Using CW, SSB and Digital Modes
- The HamSCI Website Ultimate Resource:
- https://hamsci.org/contest-info
- https://hamsci.org/seqp-faqs
- https://hamsci.org/seqp-rules
- 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 annullarity or totality) for the research team.

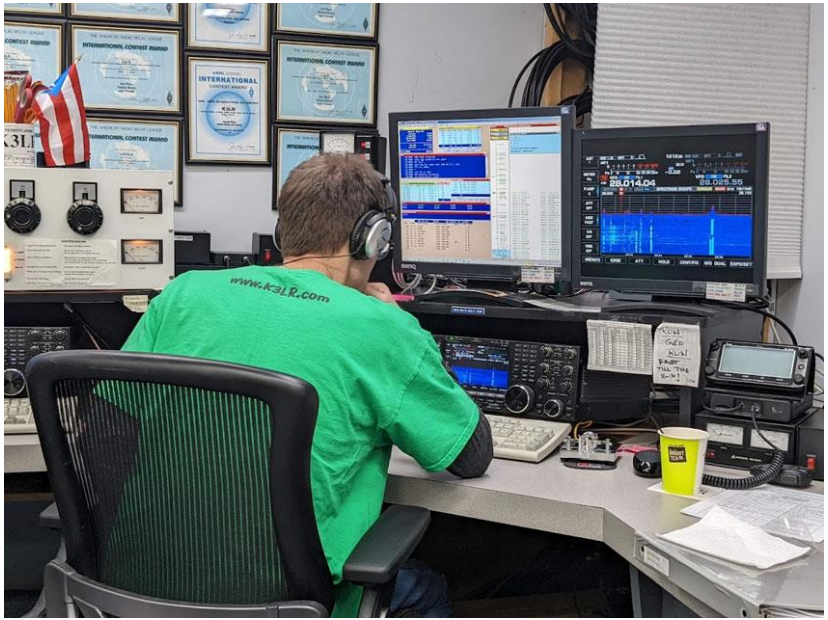
II) Objective

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.

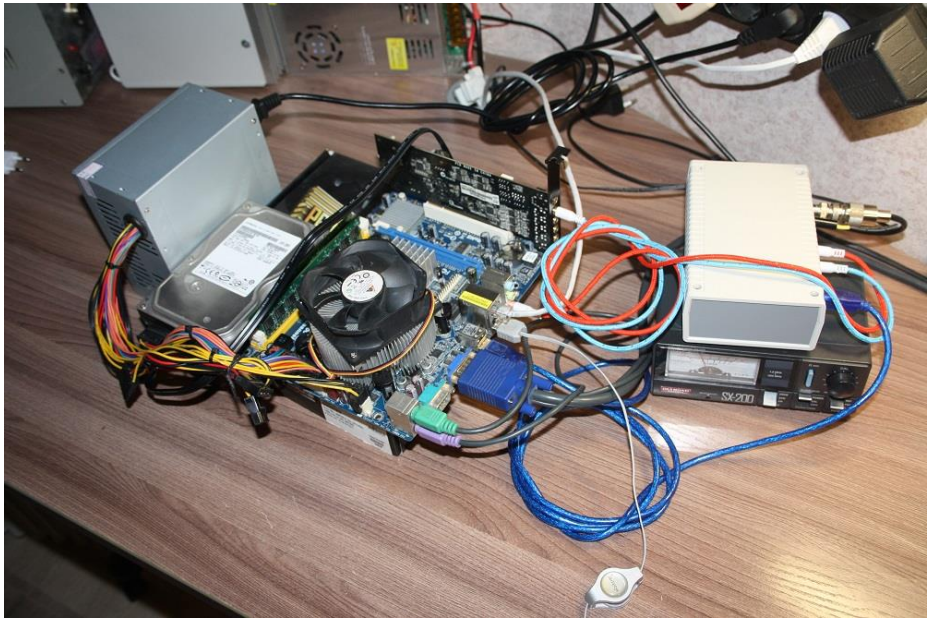
Appealing to a Broad Range of Interests

Typical QSO Party Participant



George N3GJ, operating at K3LR, courtesy of [k3lr.com](k3lr.com)

Homebrew WSPR Station

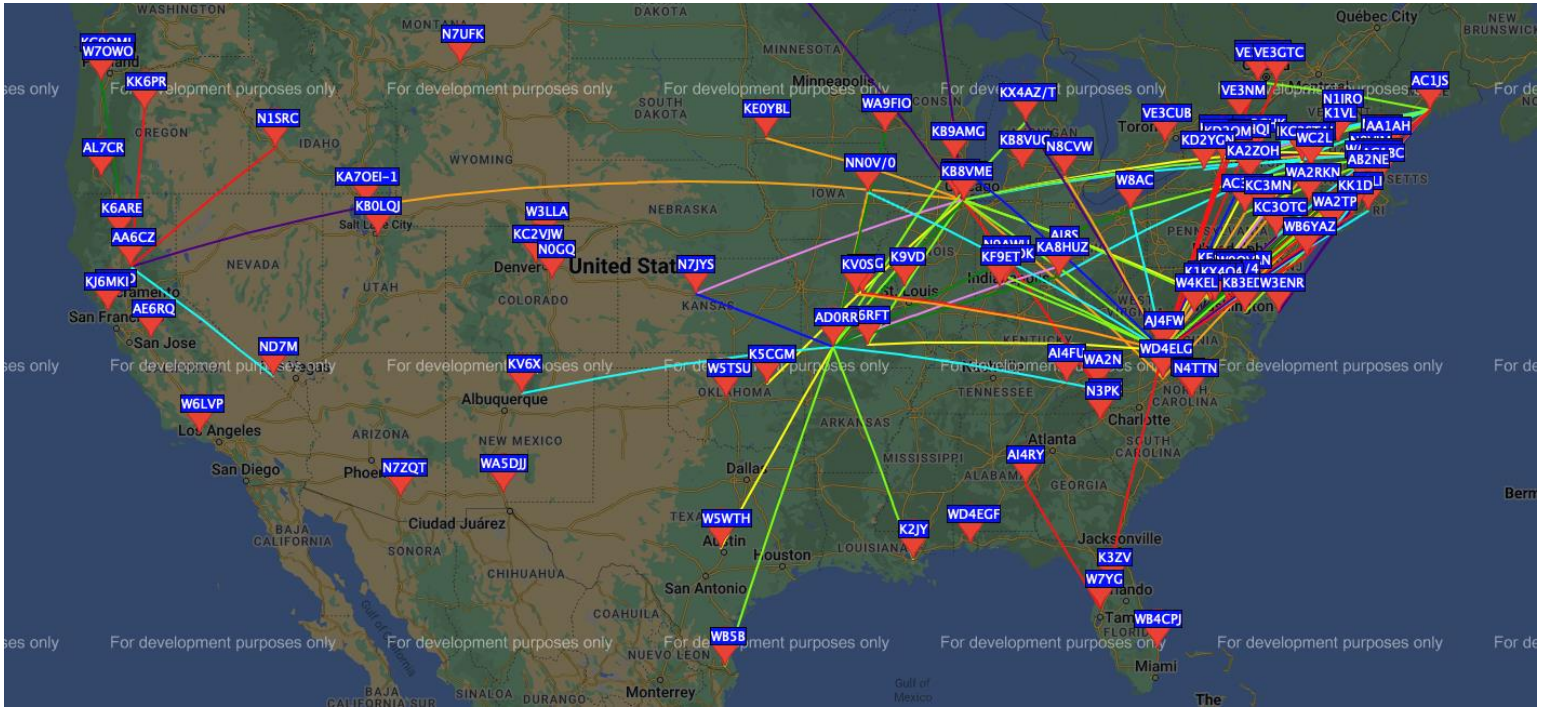


Courtesy of wsprnet.org

Inexpensive Single Band WSPR Transmitter

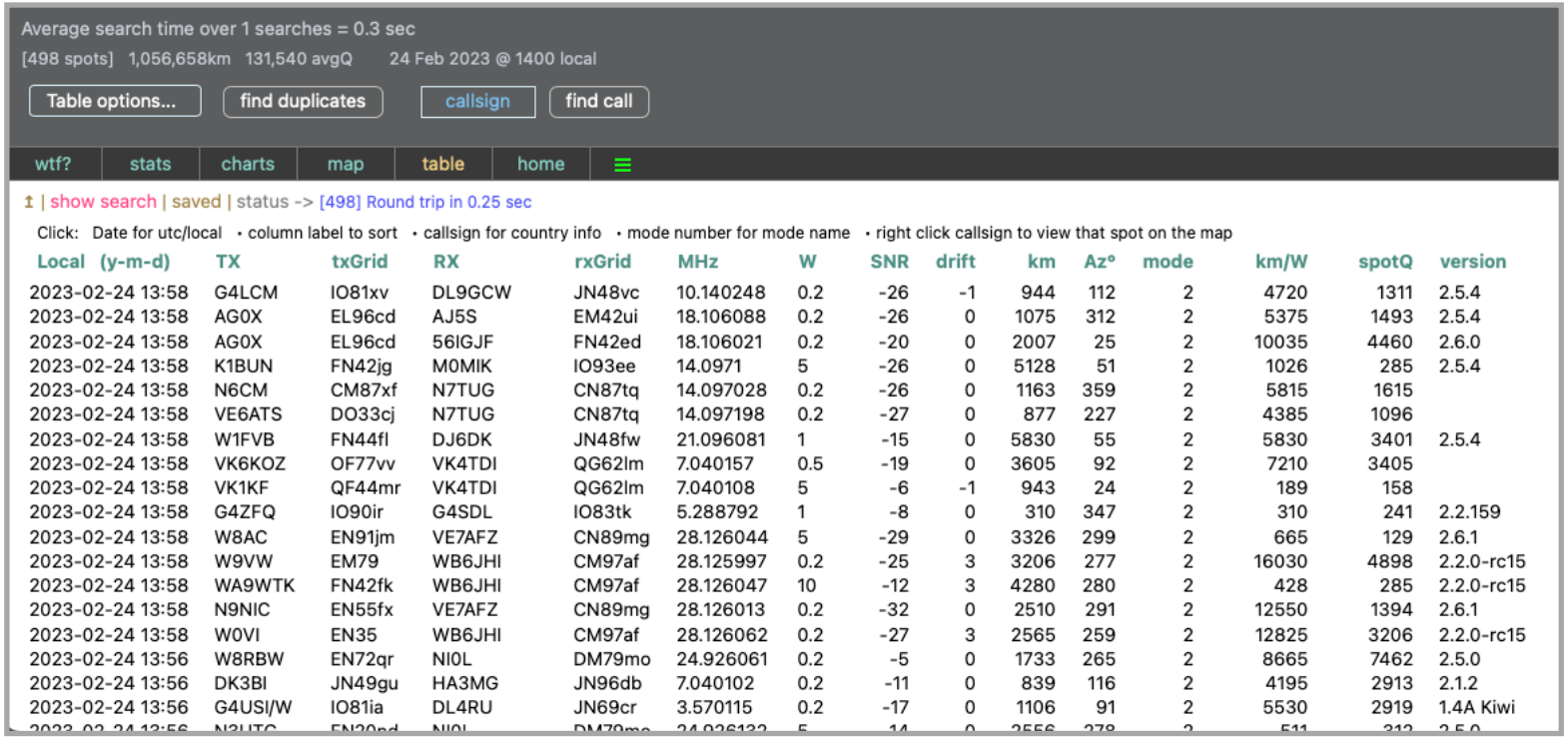
- **W**eak **S**ignal **P**ropagation **R**eporter "**WSPR**" Digital Mode for Beacon Transmissions
- Transmission & Reception Largely Automatic
- Results Appear in Real-Time Data Stored for Later Research on the Internet

Map of Signal Spotters and Signal Paths



https://www.wsprnet.org/drupal/wsprnet/map

Database of Signal Spots

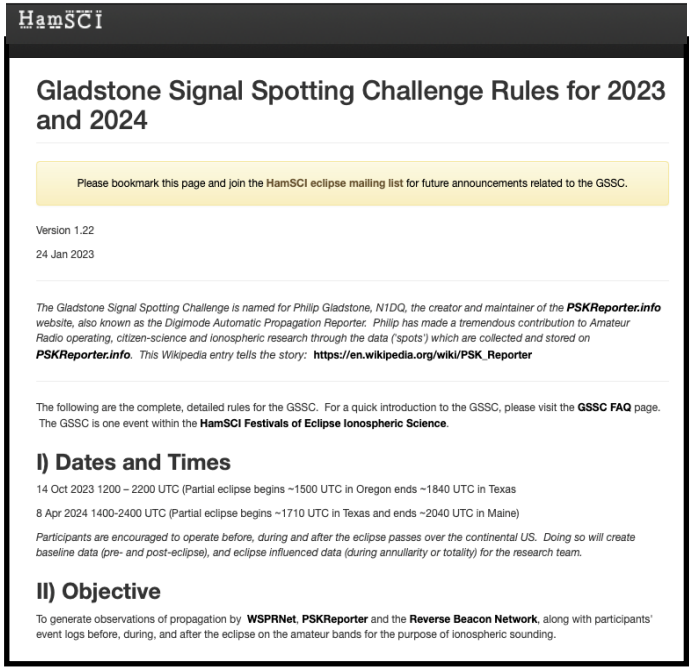


Local (y-m-d)	TX	txGrid	RX	rxGrid	MHz	W	SNR	drift	km	Az°	mode	km/W	spotQ	version
2023-02-24 13:58	G4LCM	IO81xv	DL9GCW	JN48vc	10.140248	0.2	-26	-1	944	112	2	4720	1311	2.5.4
2023-02-24 13:58	AG0X	EL96cd	AJ5S	EM42ui	18.106088	0.2	-26	0	1075	312	2	5375	1493	2.5.4
2023-02-24 13:58	AG0X	EL96cd	56IGJF	FN42ed	18.106021	0.2	-20	0	2007	25	2	10035	4460	2.6.0
2023-02-24 13:58	K1BUN	FN42jg	M0MIK	IO93ee	14.0971	5	-26	0	5128	51	2	1026	285	2.5.4
2023-02-24 13:58	N6CM	CM87xf	N7TUG	CN87tq	14.097028	0.2	-26	0	1163	359	2	5815	1615	
2023-02-24 13:58	VE6ATS	DO33cj	N7TUG	CN87tq	14.097198	0.2	-27	0	877	227	2	4385	1096	
2023-02-24 13:58	W1FVB	FN44fl	DJ6DK	JN48fw	21.096081	1	-15	0	5830	55	2	5830	3401	2.5.4
2023-02-24 13:58	VK6KOZ	OF77vv	VK4TDI	QG62lm	7.040157	0.5	-19	0	3605	92	2	7210	3405	
2023-02-24 13:58	VK1KF	QF44mr	VK4TDI	QG62lm	7.040108	5	-6	-1	943	24	2	189	158	
2023-02-24 13:58	G4ZFQ	IO90ir	G4SDL	IO83tk	5.288792	1	-8	0	310	347	2	310	241	2.2.159
2023-02-24 13:58	W8AC	EN91jm	VE7AFZ	CN89mg	28.126044	5	-29	0	3326	299	2	665	129	2.6.1
2023-02-24 13:58	W9VW	EM79	WB6JHI	CM97af	28.125997	0.2	-25	3	3206	277	2	16030	4898	2.2.0-rc15
2023-02-24 13:58	WA9WTK	FN42fk	WB6JHI	CM97af	28.126047	10	-12	3	4280	280	2	428	285	2.2.0-rc15
2023-02-24 13:58	N9NIC	EN55fx	VE7AFZ	CN89mg	28.126013	0.2	-32	0	2510	291	2	12550	1394	2.6.1
2023-02-24 13:58	W0VI	EN35	WB6JHI	CM97af	28.126062	0.2	-27	3	2565	259	2	12825	3206	2.2.0-rc15
2023-02-24 13:56	W8RBW	EN72qr	NI0L	DM79mo	24.926061	0.2	-5	0	1733	265	2	8665	7462	2.5.0
2023-02-24 13:56	DK3BI	JN49gu	HA3MG	JN96db	7.040102	0.2	-11	0	839	116	2	4195	2913	2.1.2
2023-02-24 13:56	G4USI/W	IO81ia	DL4RU	JN69cr	3.570115	0.2	-17	0	1106	91	2	5530	2919	1.4A Kiwi

http://wspr.rocks

Gladstone Signal Spotting Challenge

- We Hope for Significantly Higher Spot Counts in 2023 and 2024
- The HamSCI Website has Details on the Challenge and Links to WSPR and FST4W
- https://hamsci.org/contest-info
- https://hamsci.org/gssc-faqs
- https://hamsci.org/gssc-rules
- Results Will Be Published



HamSCI

Gladstone Signal Spotting Challenge Rules for 2023 and 2024

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

Version 1.22

24 Jan 2023

*The Gladstone Signal Spotting Challenge is named for Philip Gladstone, N1DQ, the creator and maintainer of the **PSKReporter.info** website, also known as the Digimode Automatic Propagation Reporter. Philip has made a tremendous contribution to Amateur Radio operating, citizen-science and ionospheric research through the data ('spots') which are collected and stored on **PSKReporter.info**. This Wikipedia entry tells the story:* **https://en.wikipedia.org/wiki/PSK_Reporter**

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II) Objective

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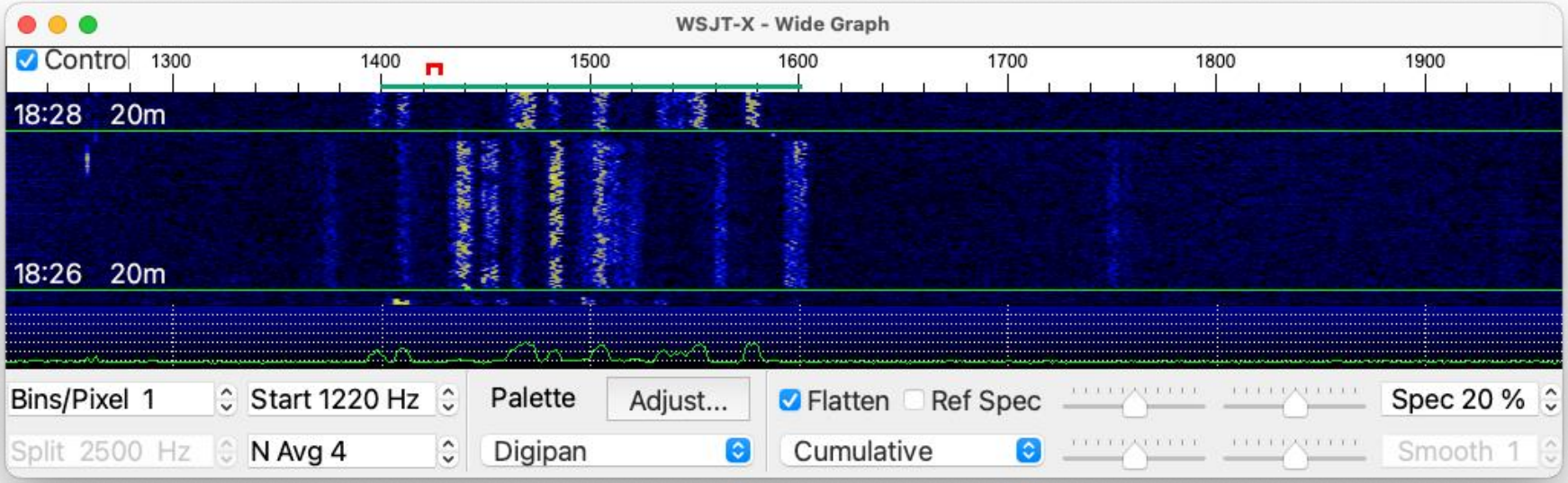
Gladstone Signal Spotting Challenge

- Appeals to Those Already Interested in Radio Wave Propagation
- Employs Digital Modes for Both Short Term Feedback and Long Term Studies of HF Propagation

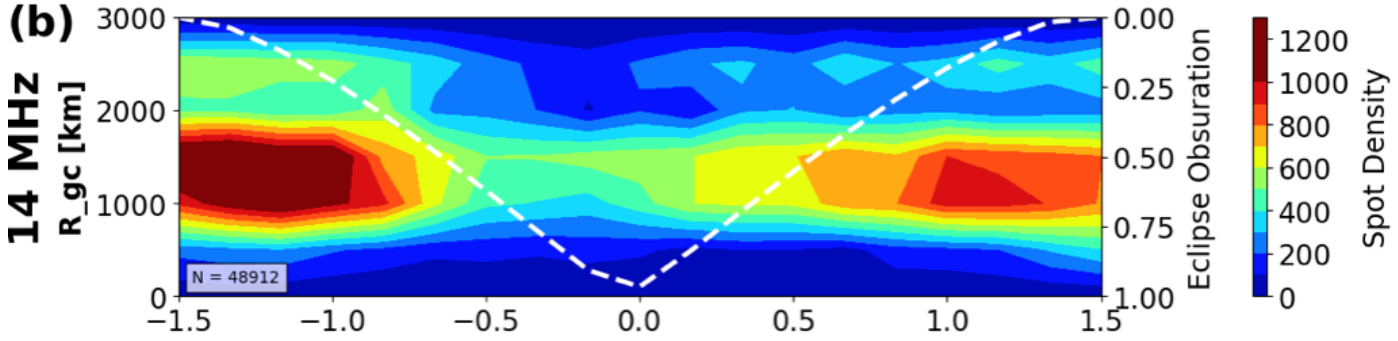


Gladstone Signal Spotting Challenge

- Commonly Used Mode Whose data are Useful for Visualization, is WSPR (**W**eak **S**ignal **P**ropagation **R**eporter, c. 2010)
- We Also Promote FST4W to Yield a Richer Data Set
- Equipment Needs are Very Simple - Racks Full of Gear are Definitely *not* Required!

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

SEQP 2017: RBN Spot Observations

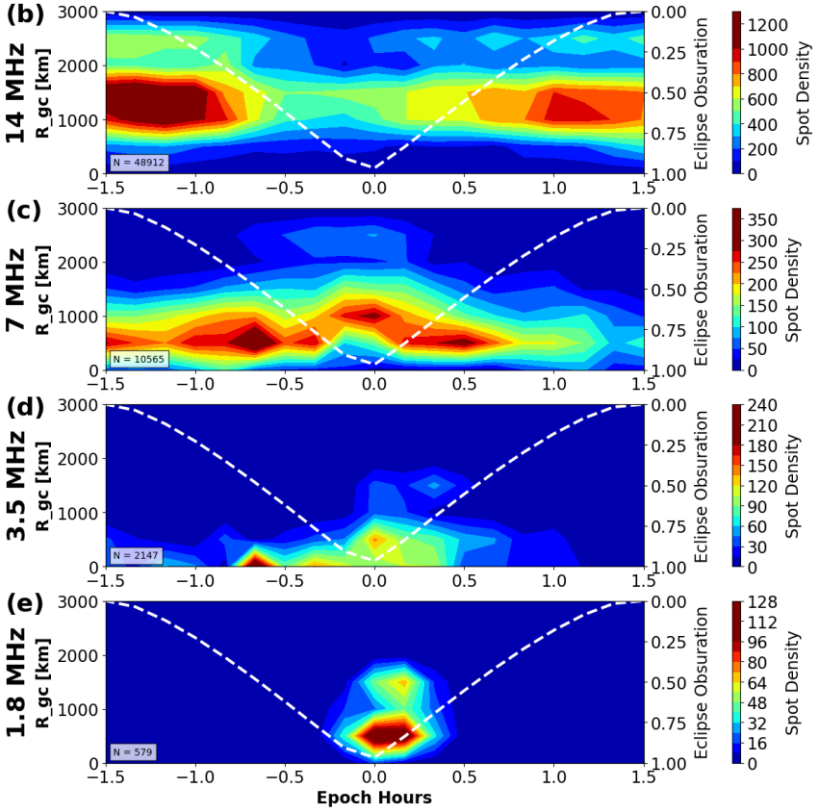


RBN Spot Observations Near the Time of Totality

Great circle distance between transmitter and receiver versus epoch for frequencies in the amateur radio bands color coded by spot density.
For the contours, the underlying grid is 500 km by 10-min bins.
The dashed white line shows obscuration at a representative point 40° N, 100° W (roughly the middle of the continental US).

(Frissell et al, 2018)

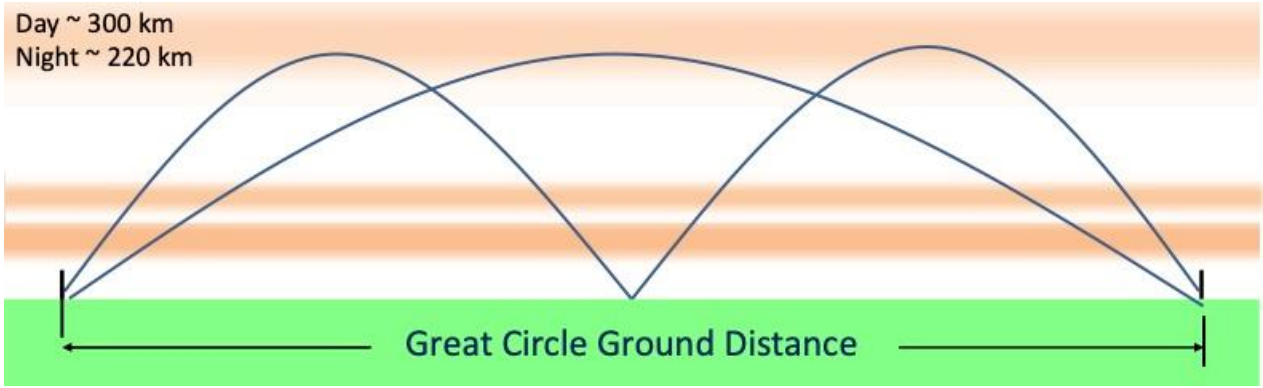
SEQP 2017: RBN Spot Observations



(Frissell et al, 2018)

Time Delay of Arrival (TDOA) Event

- For Science-Minded Amateurs to Be Part of a Controlled Experiment
- Transmit/Receive “Chirp Signals” Custom Generated for Your Station/Callsign During Eclipses
- Measure Changes in the Observed F2 Layer Height as the 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

Grape Personal Space Weather Stations

HamSCI PSWS Project Placing Low-Cost SDRs in Dozens (Hundreds?) of Locations Across the Americas.

The Grape PSWS serves a very specific Purpose:

Recording Changes in the Ionosphere through Measurements of Doppler Frequency Shifts Observed by 24/7 Monitoring of Frequency Standard Stations **WWV/H** & **CHU**

Grape PSWS receiver/mixer board

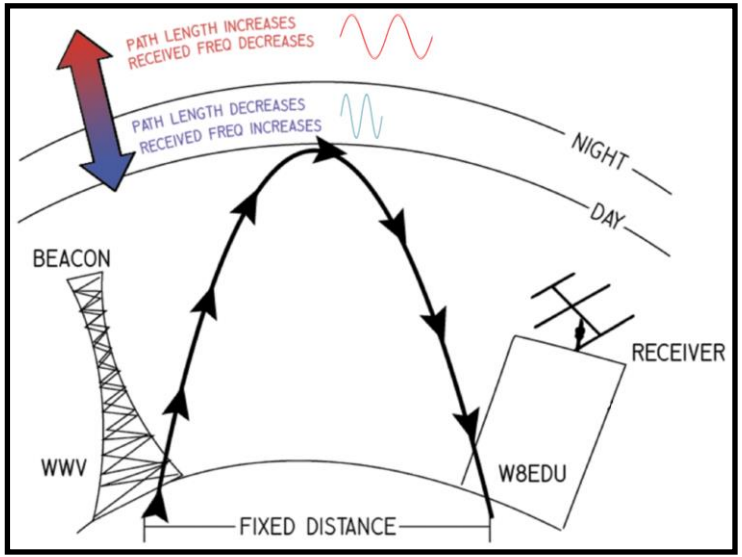
0.88 x 1.56 inches

Grape PSWS - For More Information

the Sun Greatly Affects the Ionosphere

We Can Sense the Bottom Side by

Measuring the Received Frequency of Stations such as WWV/H & CHU 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

In Summary: FoEIS is Fun, with a Purpose

Message to hams: Long term benefits of participation

- Improved Understanding of HF Propagation
- Improved Models of the Ionosphere
- More Accurate Propagation Forecasts
- Who Knows What Else?
- Scientific Discoveries are Never Planned, Only Experienced

FoEIS:
Festival of
Eclipse
Ionospheric
Science

Interested in Participating?

- Follow HamSCI.org/eclipse and Join https://groups.google.com/g/hamsci-eclipse
- Pre-register for the Events at HamSCI.org/eclipse
- *Operate in the SEQP, TDOA Event ,or Build a Grape Receiver!*

Publications

HamSCI Research Presented and Published in Many Different Fora Examples include:

- American Geophysical Union Fall Meetings
- 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

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 Produced and Provided HF radio Observations Mentioned Here Especially Operators of the Reverse Beacon Network (RBN, reversebeacon.net), the Weak Signal Propagation Reporting Network (WSPRNet, wsprnet.org), PSKReporter (pskreporter.info) qrz.com, and 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).

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