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HamSCI Festivals of Eclipse Ionospheric Science

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[4]Space Science Institute, Boulder, CO, USA
[5]The University of Alabama, Tuscaloosa, AL, USA
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[7]Dartmouth College, Hanover, NH US
[8]Syntek Technologies, Fairfax, VA, USA

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HamSCI Ham radio Science Citizen Investigation

HamSCI at 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.

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The Ionosphere

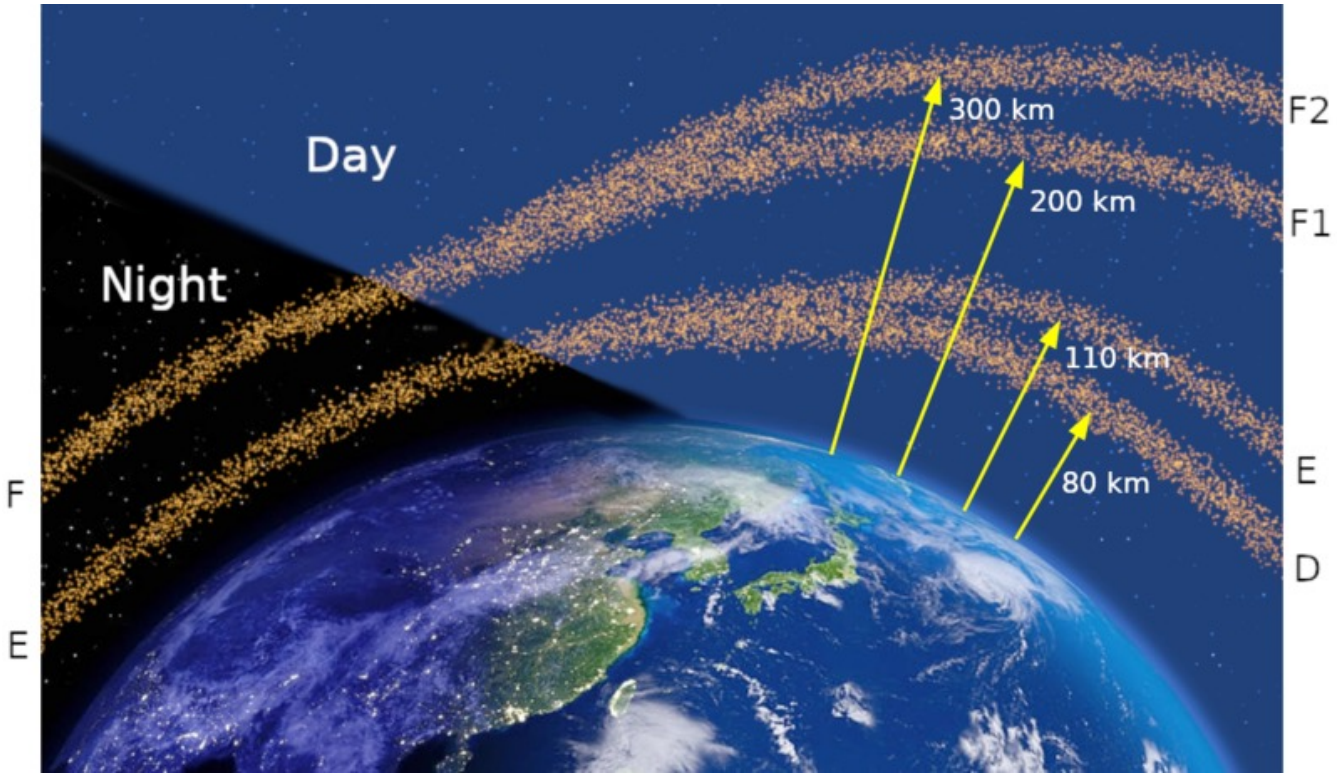
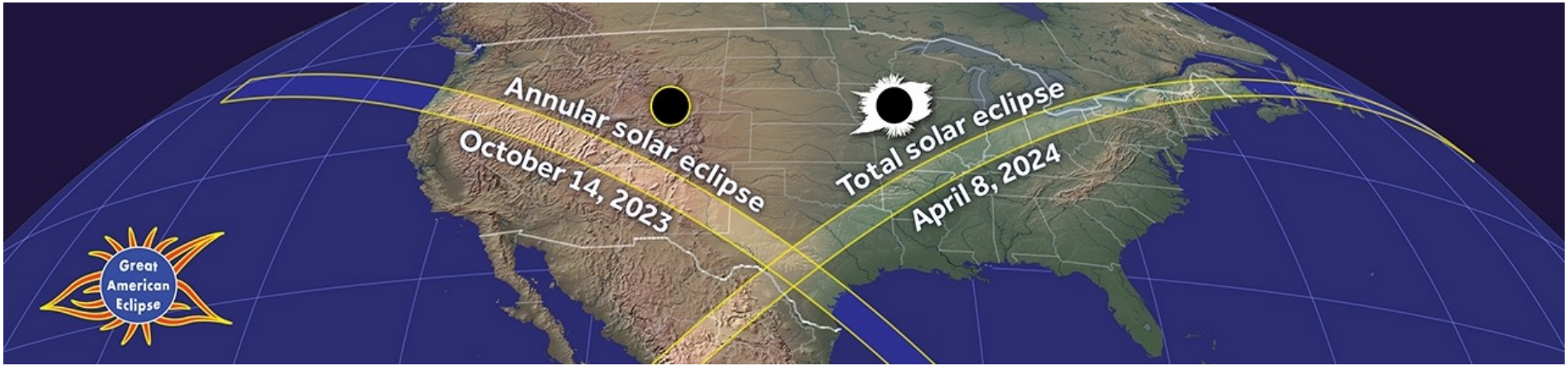


Figure by Carlos Molina (https://commons.wikimedia.org/wiki/File:Ionospheric_layers_from_night_to_day.png)

Eclipses 2023 and 2024



[https://www.greatamericaneclipse.com/]

Total and Annular Solar Eclipses

Total

Photo by Jim Sackerman, KC2ZFK

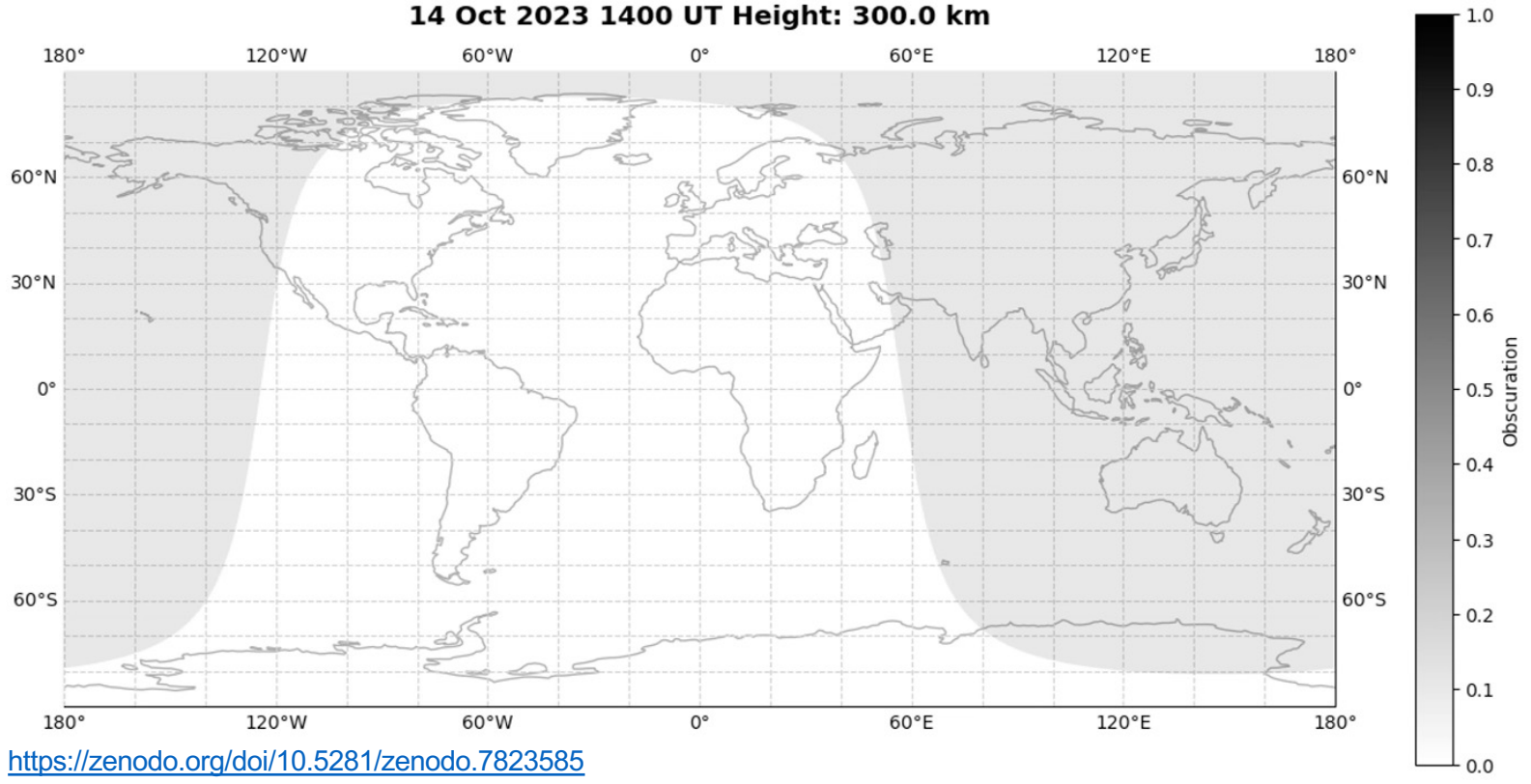
Partial

Photo By Yurakum
(https://commons.wikimedia.org/wiki/File:Sun_eclipse_25_oct_2022_in_Saratov.jpg)

Annular

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

Annular Solar Eclipse: October 14, 2023



https://zenodo.org/doi/10.5281/zenodo.7823585

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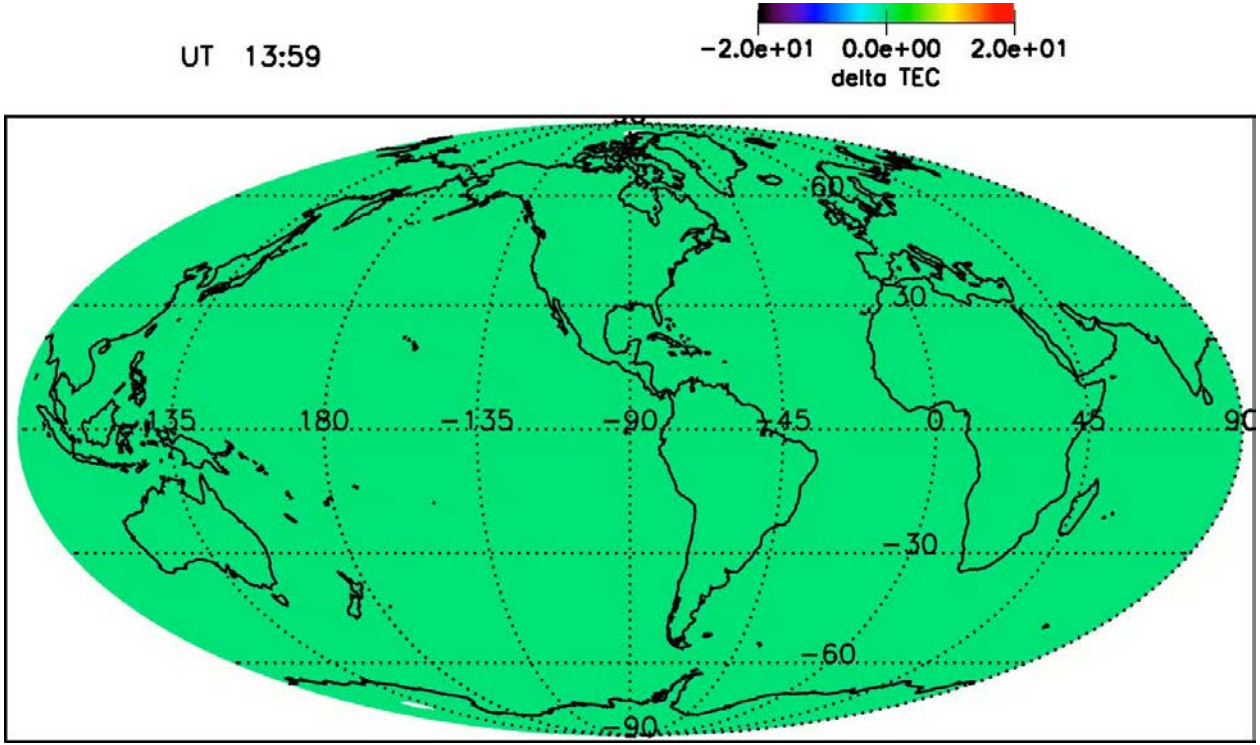
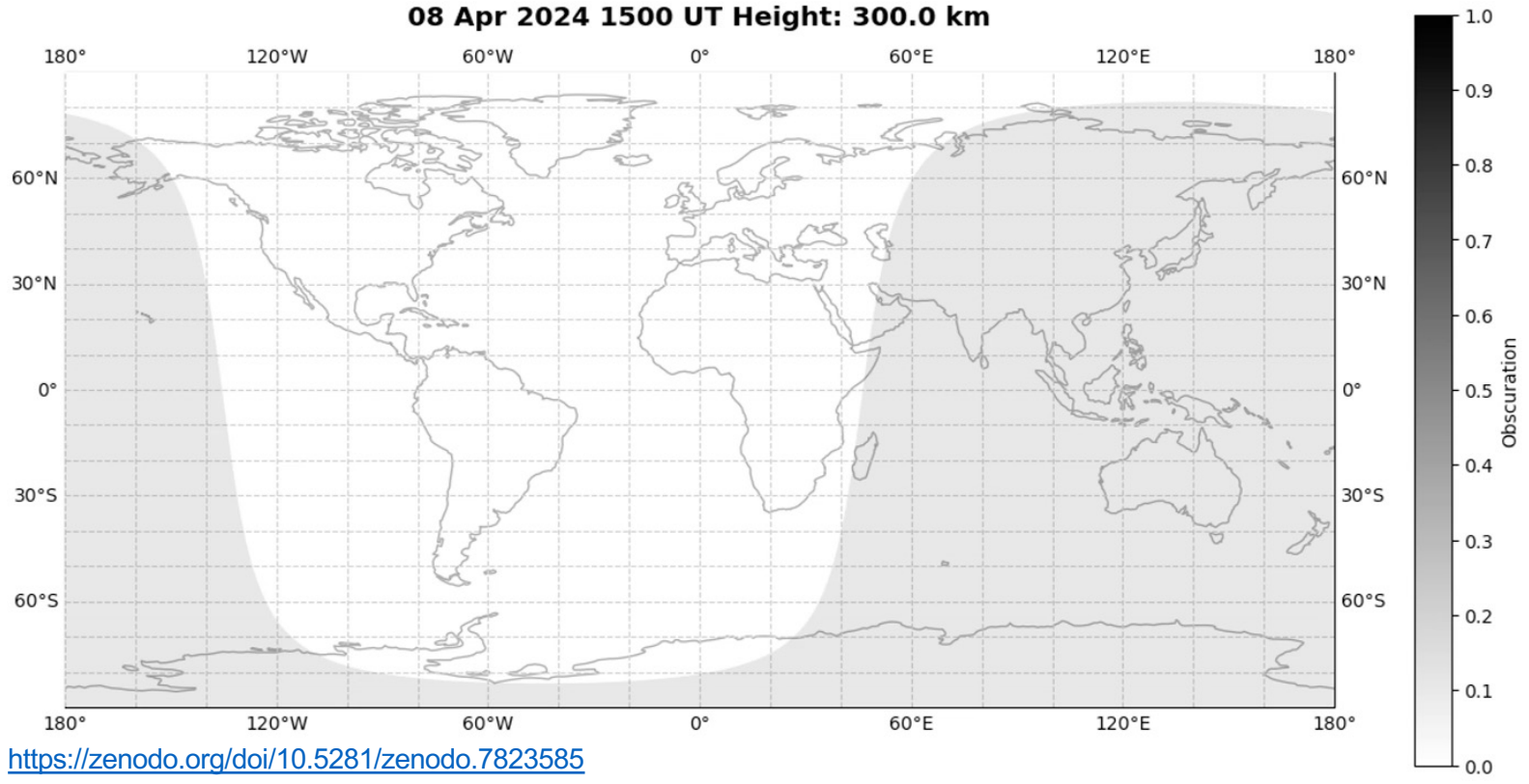
SAMI3 Annular Eclipse Ionospheric Prediction



Courtesy of Dr. Joseph Huba, Syntek Technologies

Total Solar Eclipse: April 8, 2024



https://zenodo.org/doi/10.5281/zenodo.7823585

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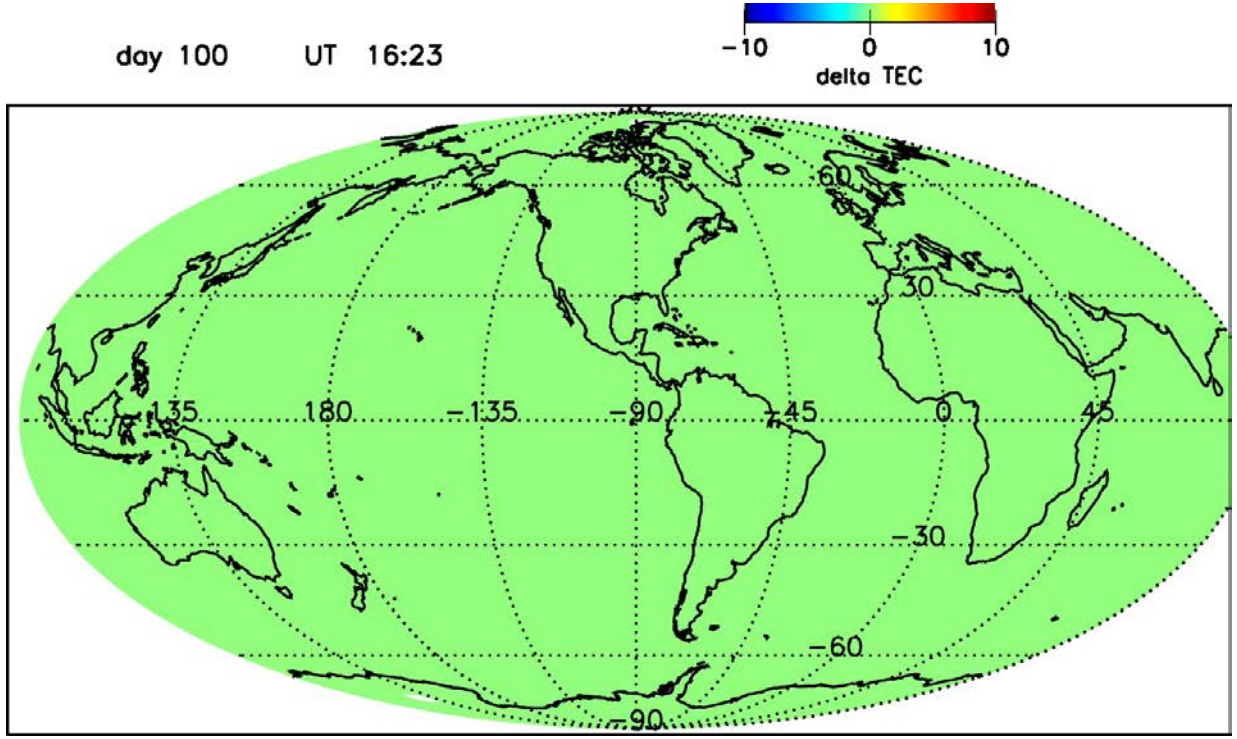
SAMI3 2024 Total Eclipse Ionospheric Prediction

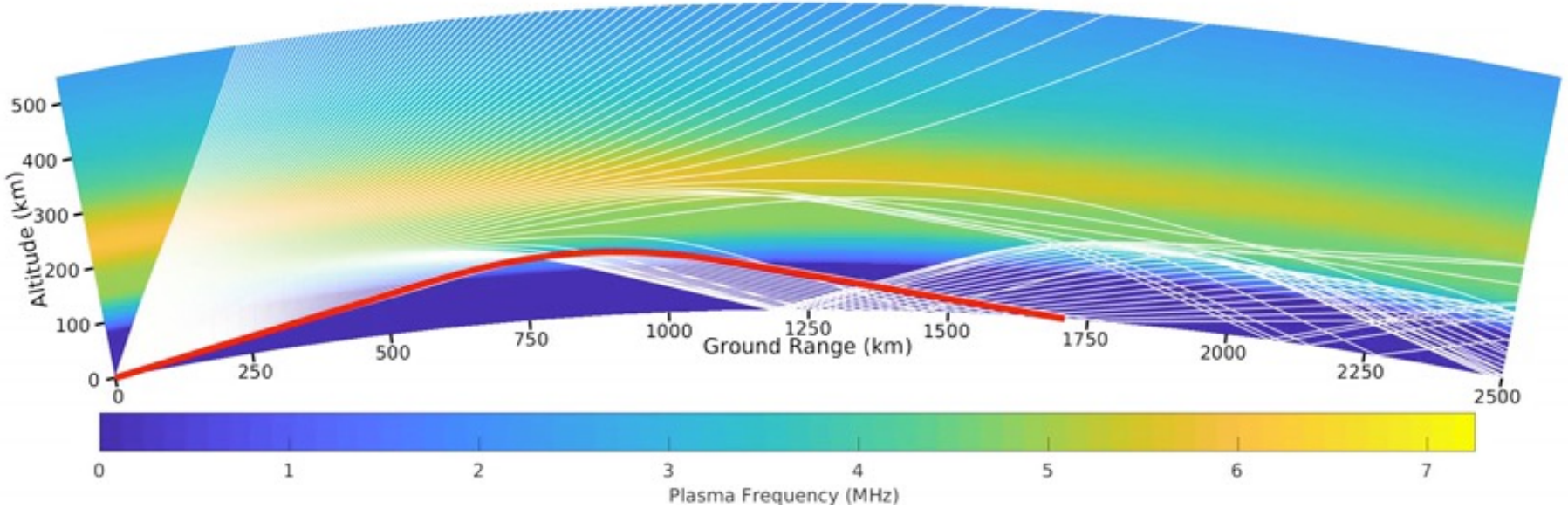


Courtesy of Dr. Joseph Huba, Syntek Technologies

Ionospheric Refraction of HF Radio Waves

Eclipsed SAMI3 - PHaRLAP Raytrace

1600 UT 21 Aug 2017 • 14.03 MHz • TX: AA2MF (Florida) • RX: WE9V (Wisconsin)



PHaRLAP: Cervera & Harris (2014), https://doi.org/10.1002/2013JA019247
SAMI3: Huba & Drob (2017), https://doi.org/10.1002/2017GL073549
Amateur Radio and the Eclipse: Frissell et al. (2018), https://doi.org/10.1029/2018GL077324

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Festivals of Eclipse Ionospheric Science

Graphic by Vikki A. Lawhon,
University of Scranton

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2023/2024 Science Questions

- Can the annular eclipse be observed in HF communications?
- How large is the disturbance?
- How long before and after maximum eclipse are eclipse effects observed?
- Is an onset-recovery asymmetry observed?
- Will results again suggest E-layer propagation for 14 MHz and F-layer for 1.8 – 7 MHz?
- How similar are the eclipse effects to dawn and dusk (grayline)?

The University of Scranton

Jesuit Liberal Arts University

Located in Downtown Scranton, PA

About 5,000 Students

A New Station for W3USR

Capabilities

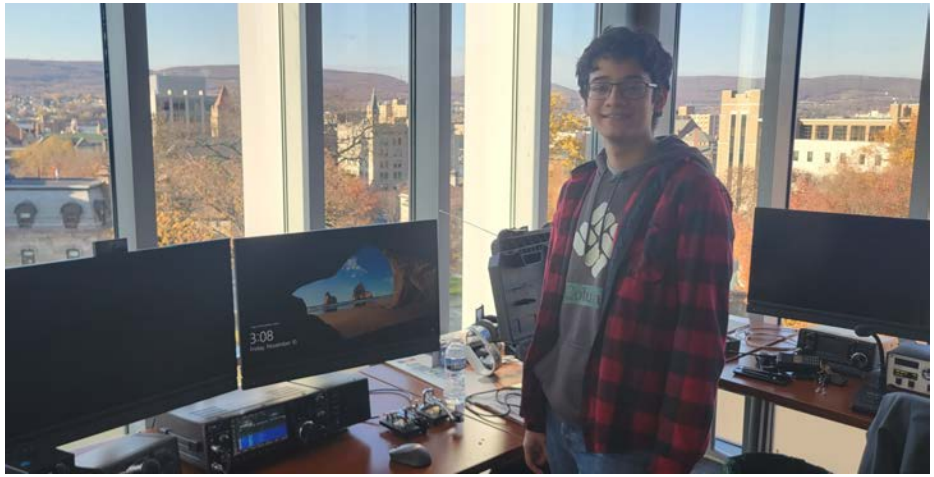
- HF
  - Icom IC-7610
  - Icom IC-7300
  - Acom 1010 Amplifier
- VHF/UHF/Satellite
  - Icom IC-9700
  - Yaesu FT-400D
- 445.875 - 82.5 W3USR Repeater

Funding & Donations

- $196,241 Grant from ARDC
- $20,000 Private Donations
- NSF, DX Engineering, and WN3A

Construction

- Professionally Designed and Installed by Broadcast Sciences, LLC (Jeff DePolo WN3A)

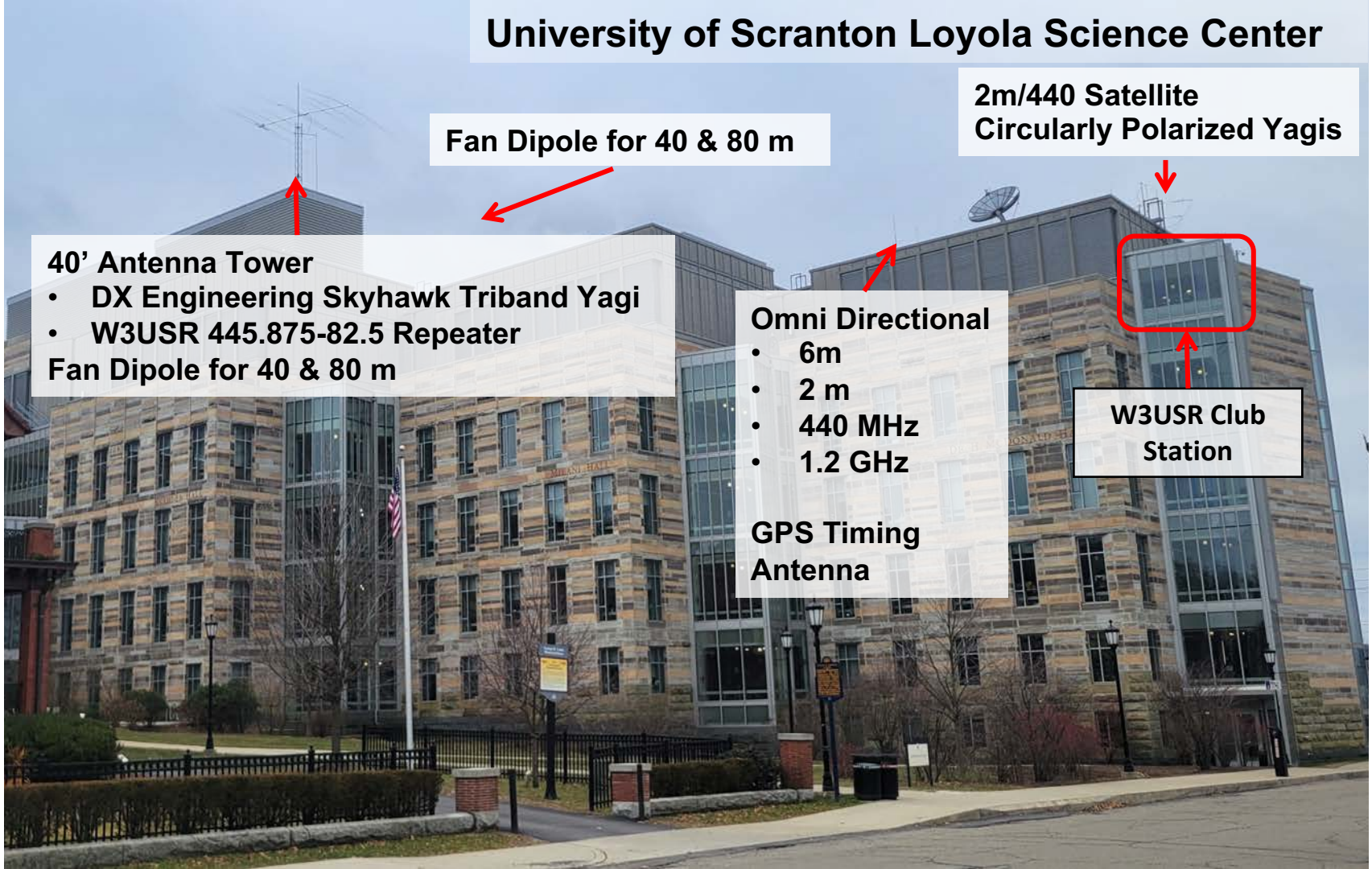


Club President Gerard Piccini in the W3USR Station

AMATEUR RADIO DIGITAL COMMUNICATIONS

University of Scranton Loyola Science Center

University of Scranton Loyola Science Center


University of Scranton Loyola Science Center
2m/440 Satellite
Circularly Polarized Yagis
Fan Dipole for 40 & 80 m
40’ Antenna Tower
• DX Engineering Skyhawk Triband Yagi
• W3USR 445.875-82.5 Repeater
Fan Dipole for 40 & 80 m
Omni Directional
• 6m
• 2 m
• 440 MHz
• 1.2 GHz
GPS Timing
Antenna
W3USR Club
Station

8 April 2024 SEQP @ W3USR

https://www.youtube.com/watch?v=y943V6xz0T0

Festivals of Eclipse Ionospheric Science

1. Solar Eclipse QSO Party (SEQP)
2. Gladstone Signal Spotting Challenge
3. Grape HF Doppler Experiment
4. WSPRDaemon Observations
5. HF Time Difference of Arrival Experiment
6. Medium Wave AM Doppler Experiment
7. Very Low Frequency (VLF) & Low Frequency (LF) Experiments

https://hamsci.org/eclipse

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Solar Eclipse QSO Party (SEQP)

- **Contest-like**
  - 2 Points CW or Digital
  - 1 Point for Phone
  - Multiply Score by # of Grids
- **Exchange**
  - RST + 6 Character Grid Square
- **Data sources**
  - Reverse Beacon Network
  - PSKReporter
  - WSPRNet
  - Participant-submitted logs

http://hamsci.org/eclipse

Graphic by Spencer Gunning

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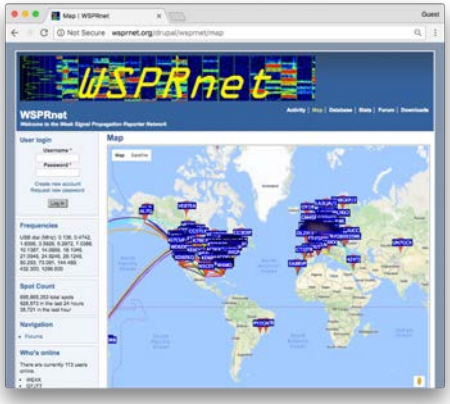
SEQP Dates and Times

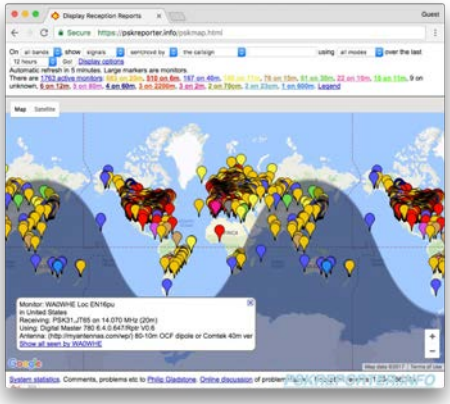
- **August 21, 2017, 1400 – 2200 UTC**
  - Partial Eclipse Begins 1604 UTC in Oregon
  - Partial Eclipse Ends 2013 UTC in South Carolina
- **October 14, 2023, 1200 – 2200 UTC**
  - Partial Eclipse Begins ~1500 UTC in Oregon
  - Partial Eclipse Ends ~1840 UTC in Texas
- **April 8, 2024, 1400-2400 UTC**
  - Partial Eclipse Begins ~1710 UTC in Texas
  - Partial Eclipse Ends ~2040 UTC in Maine

2017 SEQP Observations

RBN
reversebeacon.net



WSPRNet
wsprnet.org



PSKReporter
pskreporter.info

Observations from 21 August 2017 1400 – 2200 UT

Network	# Spots / QSOs
RBN	618,623
WSPRNet	630,132
PSKReporter	1,287,962
Participant Logs	29,809

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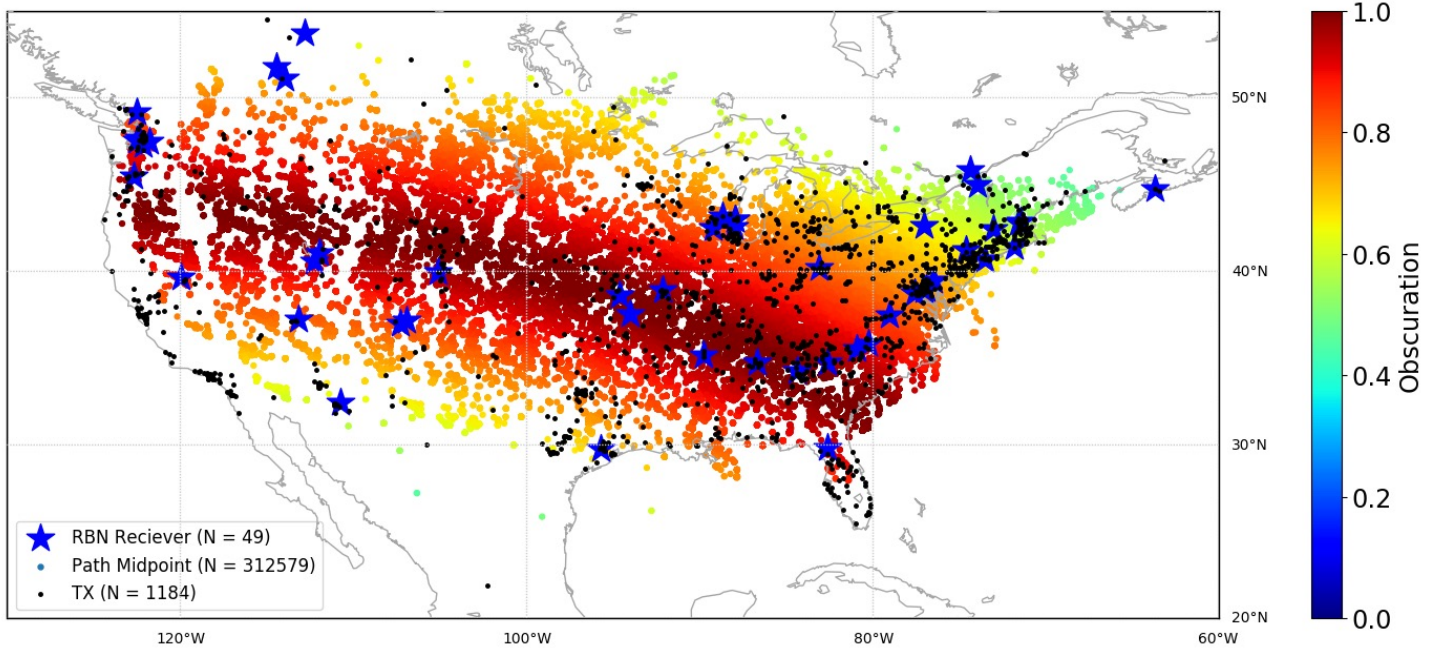
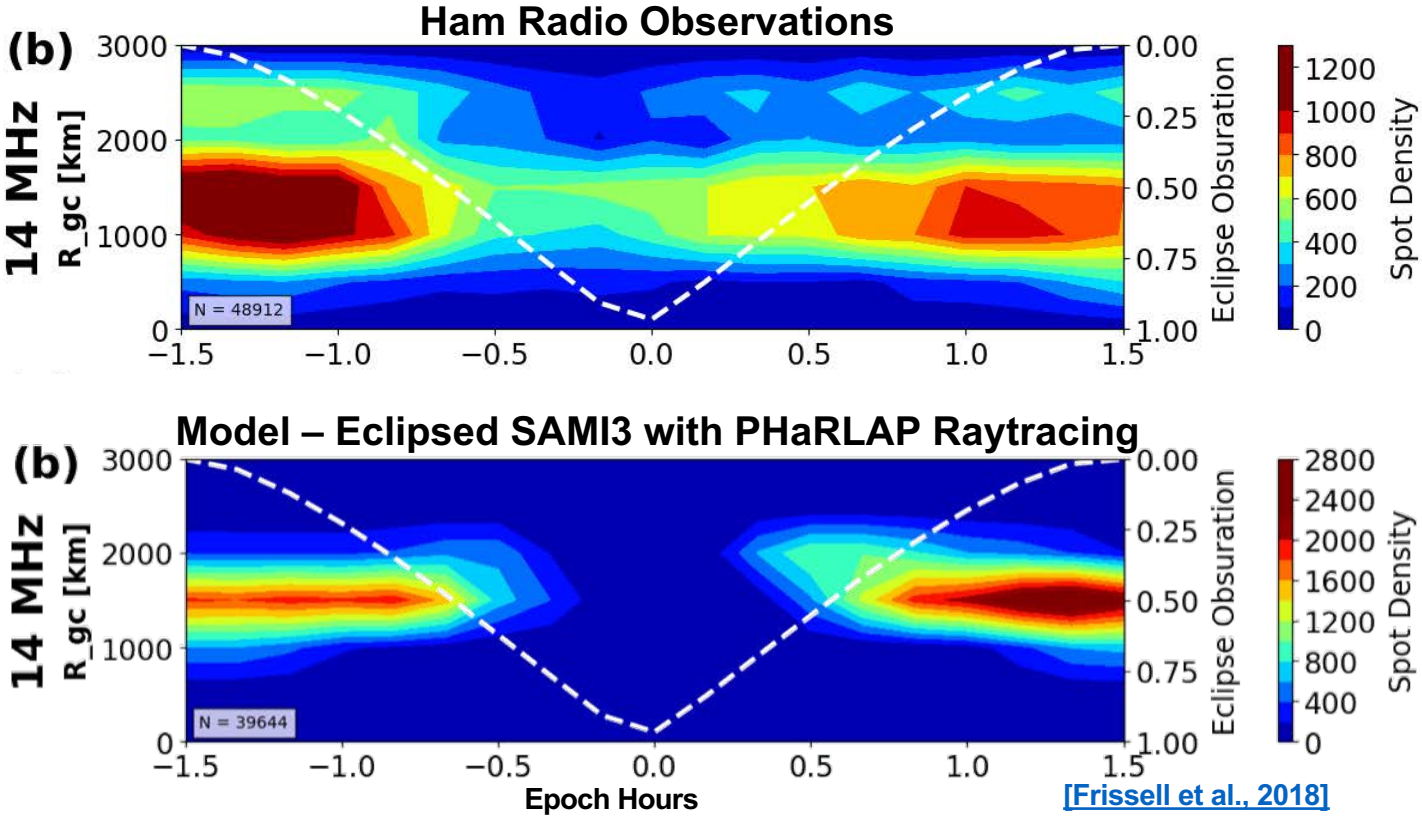
2017 Solar Eclipse QSO Party RBN Observations



(Frissell et al., 2018, *Geophysical Research Letters*, https://doi.org/10.1029/2018GL077324)

2017 SEQP Observations and Model Results



[Frissell et al., 2018]

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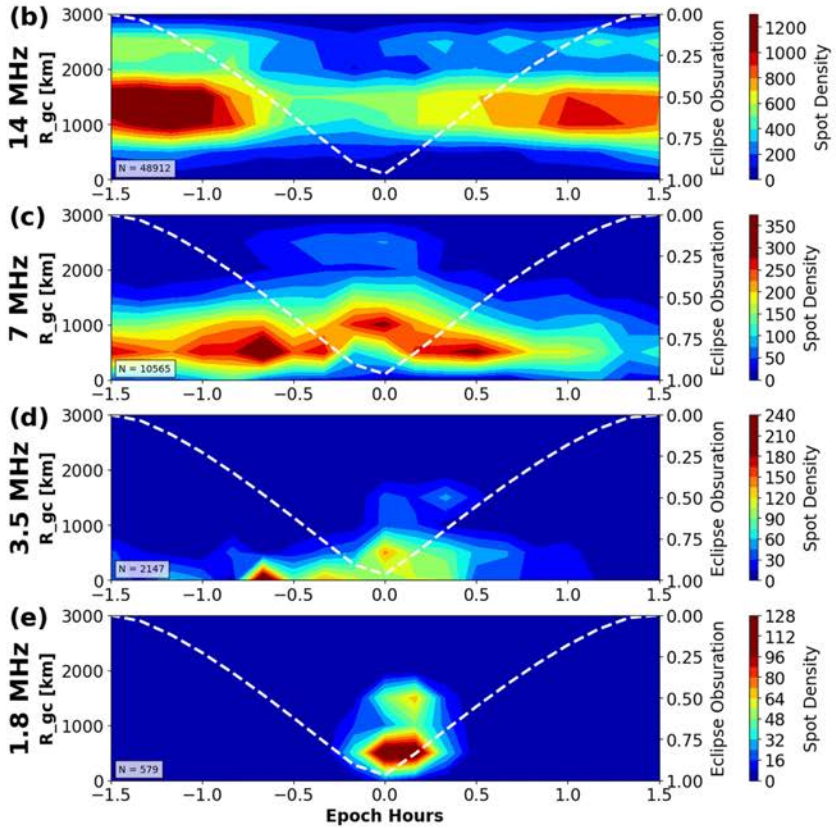
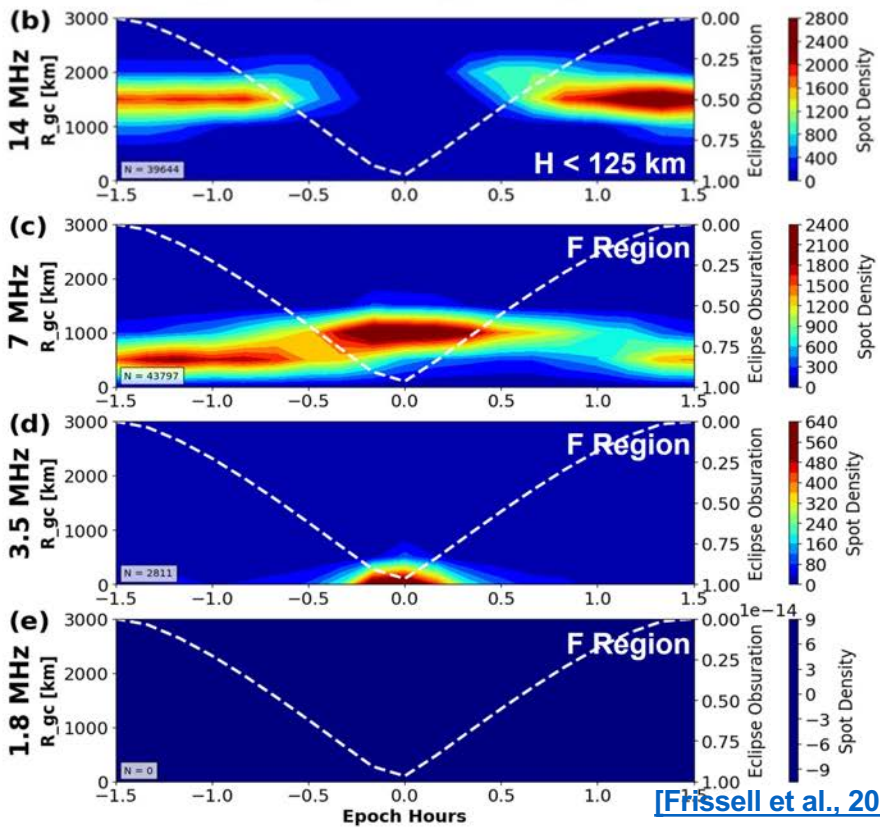
2017 SEQP Observations and Model Results





[Frissell et al., 2018]

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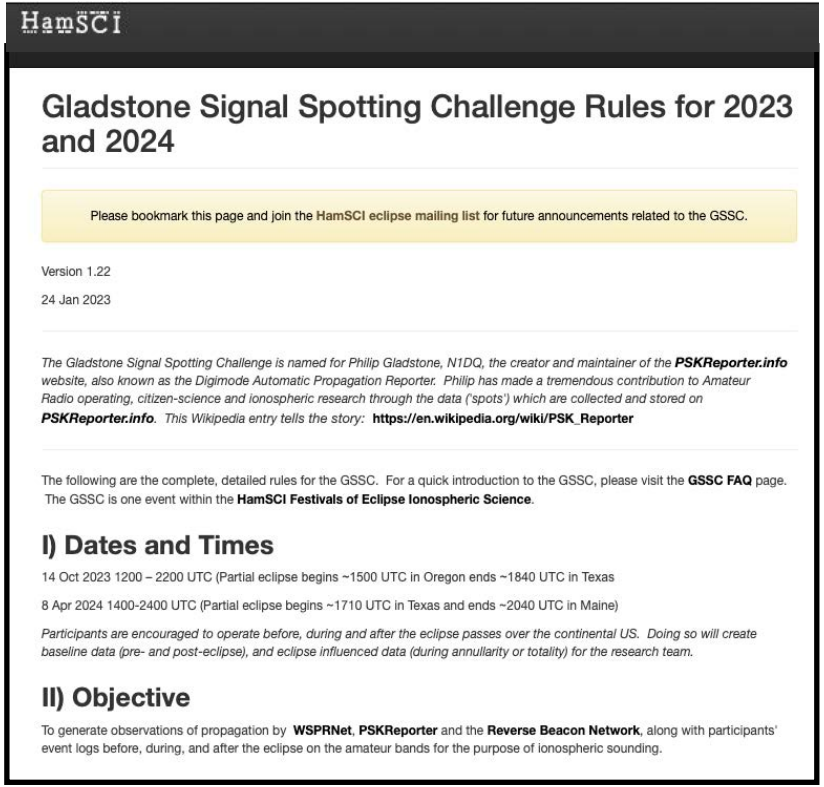
Gladstone Signal Spotting Challenge (GSSC)

- A contest for people who like running skimmers or operating WSPR and FST4W!
- Named after PSKReporter Founder/Operator Philip Gladstone N1DQ.

https://hamsci.org/eclipse



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**

The following are the complete, detailed rules for the GSSC. For a quick introduction to the GSSC, please visit the **GSSC FAQ** page. The GSSC is one event within the **HamSCI 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 **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.

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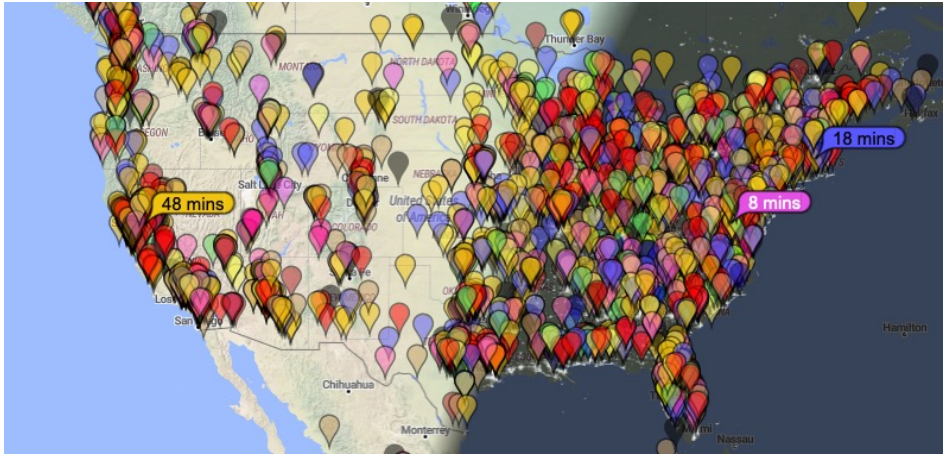
Gladstone Signal Spotting Challenge

- Two operating categories: Transmitters and Receivers. Enter one or both.
- Primary modes: WSPR (Weak Signal Propagation Reporter) and FST4W
- No logging - All ‘contacts’ are captured by spotting networks, such as PSKReporter.info and WSPRnet.org



2023 GSSC: 68 Entrants from 12 Countries

Canada

Japan

USA

Costa Rica

Norway

Scotland

Switzerland

Portugal

Reunion Island

Paraguay

Brazil

Australia

2023 GSSC Spots Received and Generated

Receiving Totals	
FT4/8*	238,539
WSPR	112,110
CW (Morse code)	3,929
Transmitting Totals	
WSPR	342,908
FST4W	18,135

*FT4/8 was part of the 2023 GSSC. For 2024, FT4/8 data will only be recognized in the SEQP.

2023 SEQP Submitted Log Data

Submitted Logs	CW QSOs	Ph QSOs	Digi QSOs	Total QSOs	Unique Calls in Logs
219 209 Single-Op 10 Multi-Op	**1,140**	**2,508**	**7,312** 222 RTTY 7,090 FT8, etc.	**10,960**	**4,419**

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2023 SEQP Timeline

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SEQP Behind the Scenes

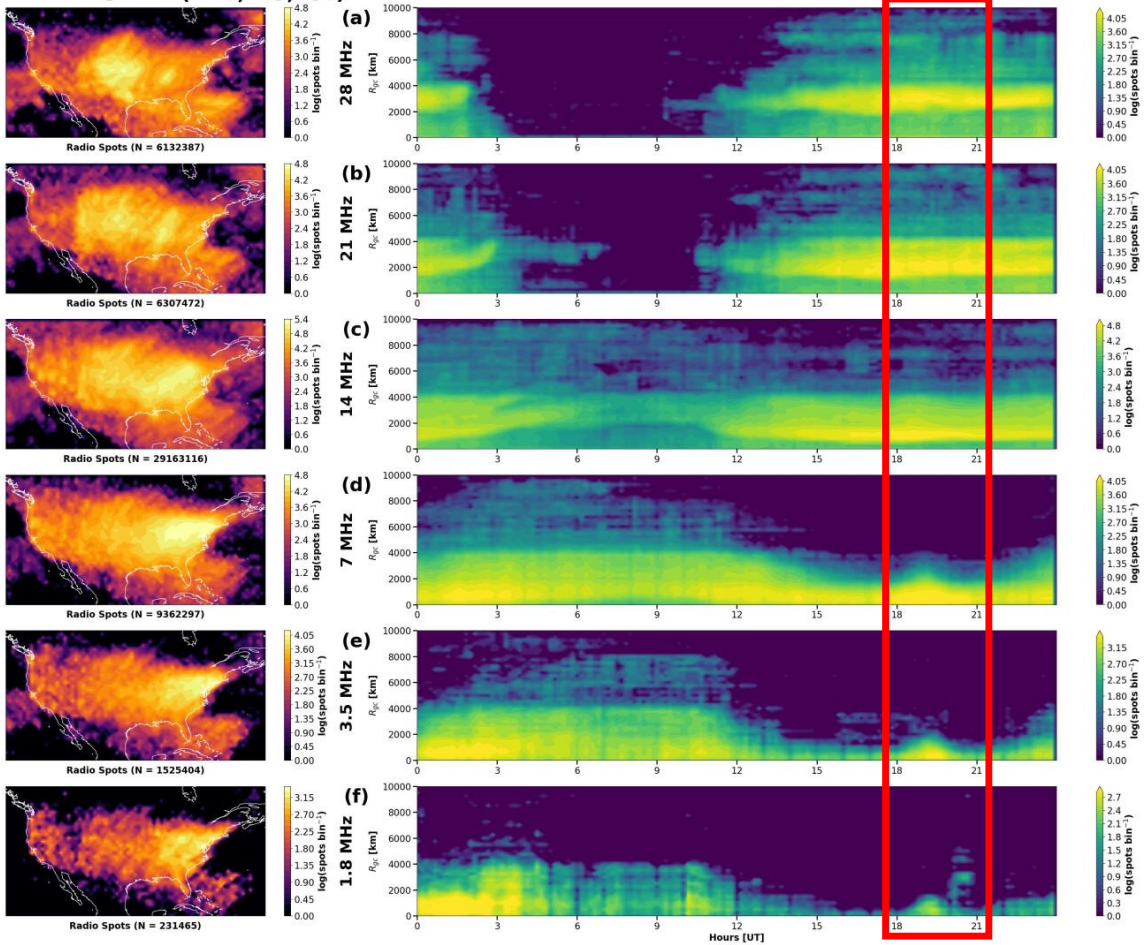
Many thanks to those who assisted with promotion, log collection and scoring:

- **Gary Mikitin, AF8A,** Amateur Radio Community Coordinator
- **Ed Efchak, WX2R** - Public Information Officer
- **McKenzie Denton, KO4GLN** - Social Media
- **Bruce Horn, WA7BNM and the WWROF** - Log upload robot and certificates
- **Adarsh Pashikanti, KN6VIS** - SEQP Scoring
- **Cam Cameron, W7CAM** - SEQP Scoring
- **ARRL -** Partnering and promotion

2024-Apr-08 00:00
Ham Radio Networks
N Spots = 52,722,141
PSKReporter: 93% (N=48,910,622)
RBN: 0% (N=91,739)
WSPRNet: 7% (N=3,719,780)

Date plotted:15 Apr 2024
Python version 3.9.12 (main, Jun 1 2022, 11:38:51)
[GCC 7.5.0]

Total Solar Eclipse



Personal Space Weather Station
Grape HF Doppler Experiment

https://hamsci.org/grape

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HF Doppler Shift

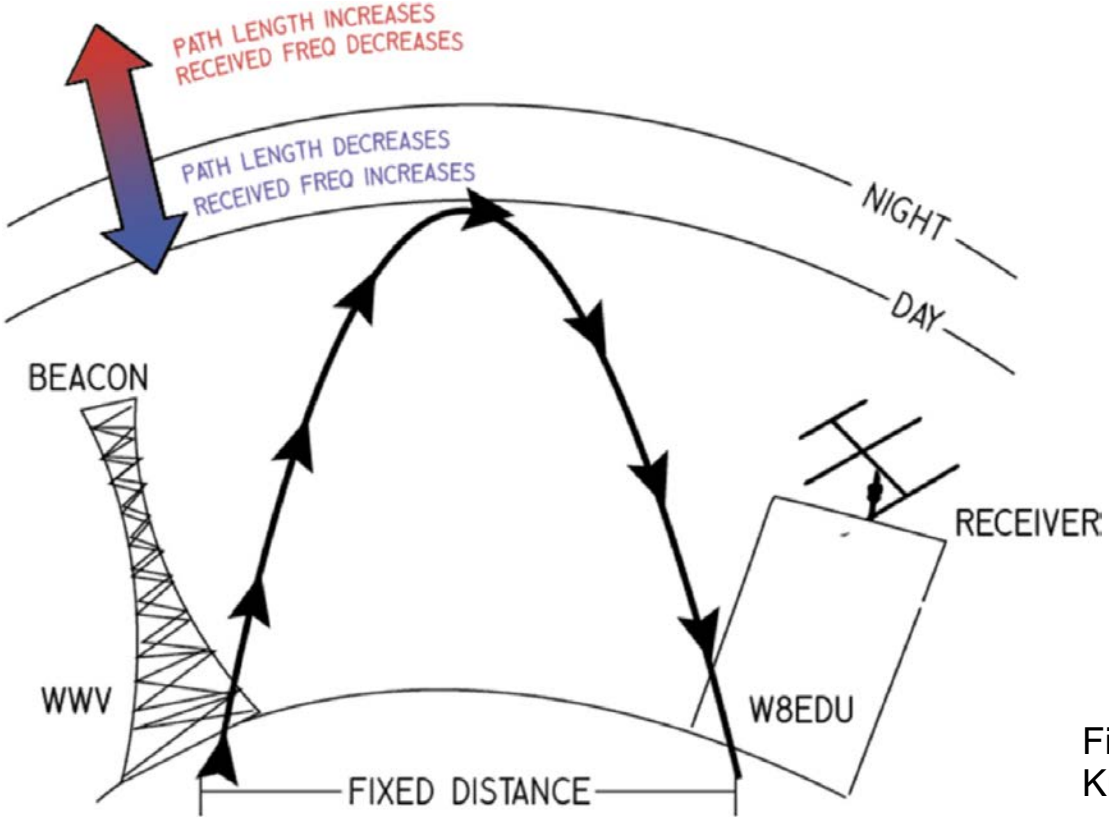

Figure by
Kristina Collins KD8OXT

Collins et al. (2023)
https://doi.org/10.5194/essd-15-1403-2023

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Grape & WSPRDaemon HF Grape Doppler Receivers

- **Developed as the "Grape" Receiver led by John Gibbons N8OBJ, Case Western Reserve University / Case Amateur Radio Club W8EDU.**
- **Primary objective** is to measure Doppler Shift of HF standards stations like WWV & CHU.

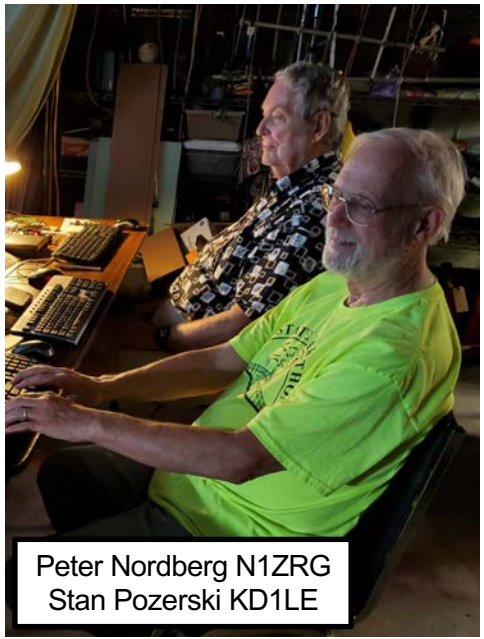
Grape v1
- Single Frequency
- Build it yourself!

Grape v2
- 3 Simultaneous Frequency Bands
- Preassembled
- 30 Deployed for Total Eclipse

WSPRDaemon-Grape
- Uses RX-888 HF SDR, KA9Q-Radio & WSPRDaemon Software
- 9 (or more!) simultaneous HF Doppler bands
- Decodes WSPR/FSTRW spots, too!

Grape Build & Distribution

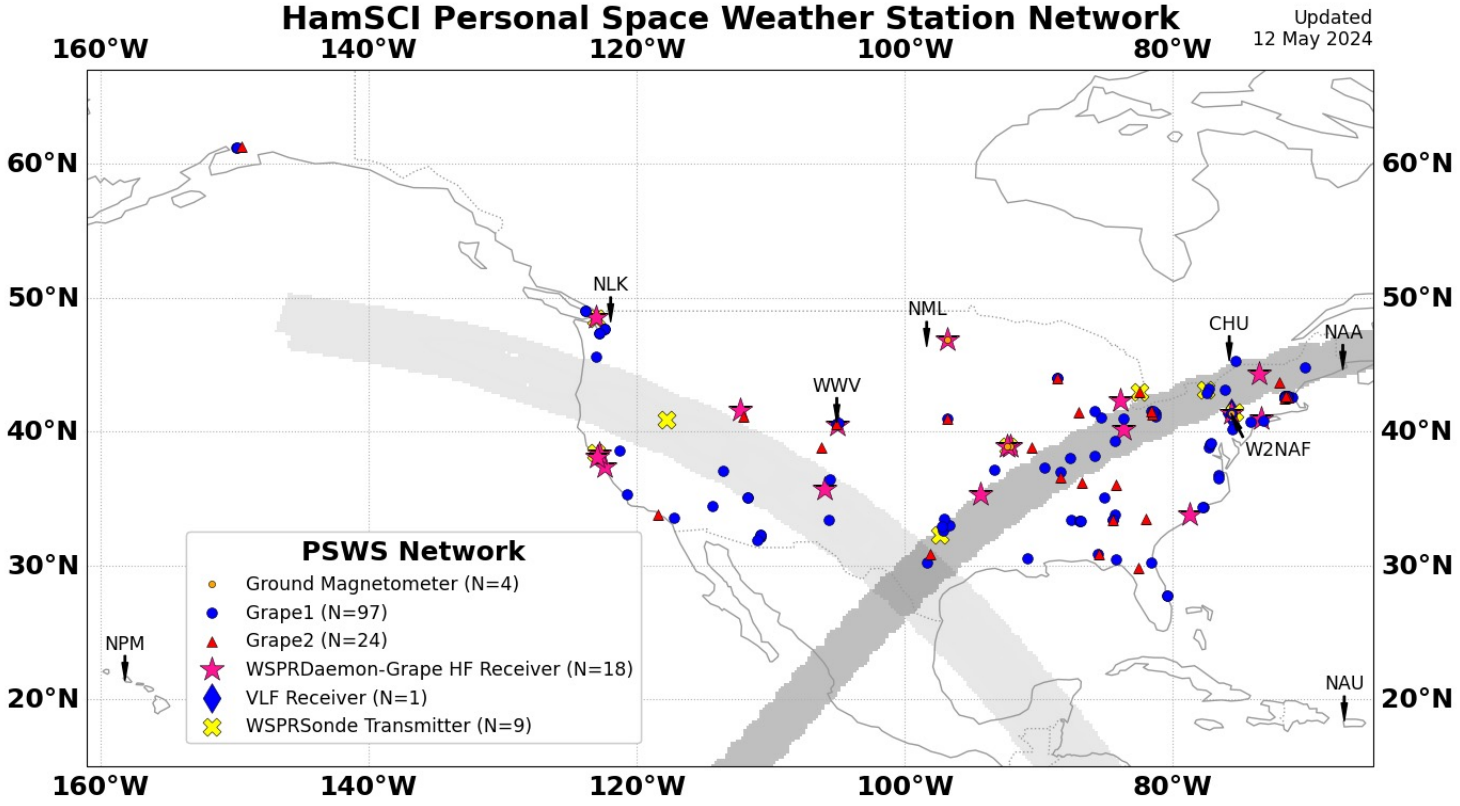
Special thanks to the New England Grape Group for building of
15 fully-assembled Grape 1s and to Gary AF8A for Grape distribution!



HamSCI PSWS Central Website

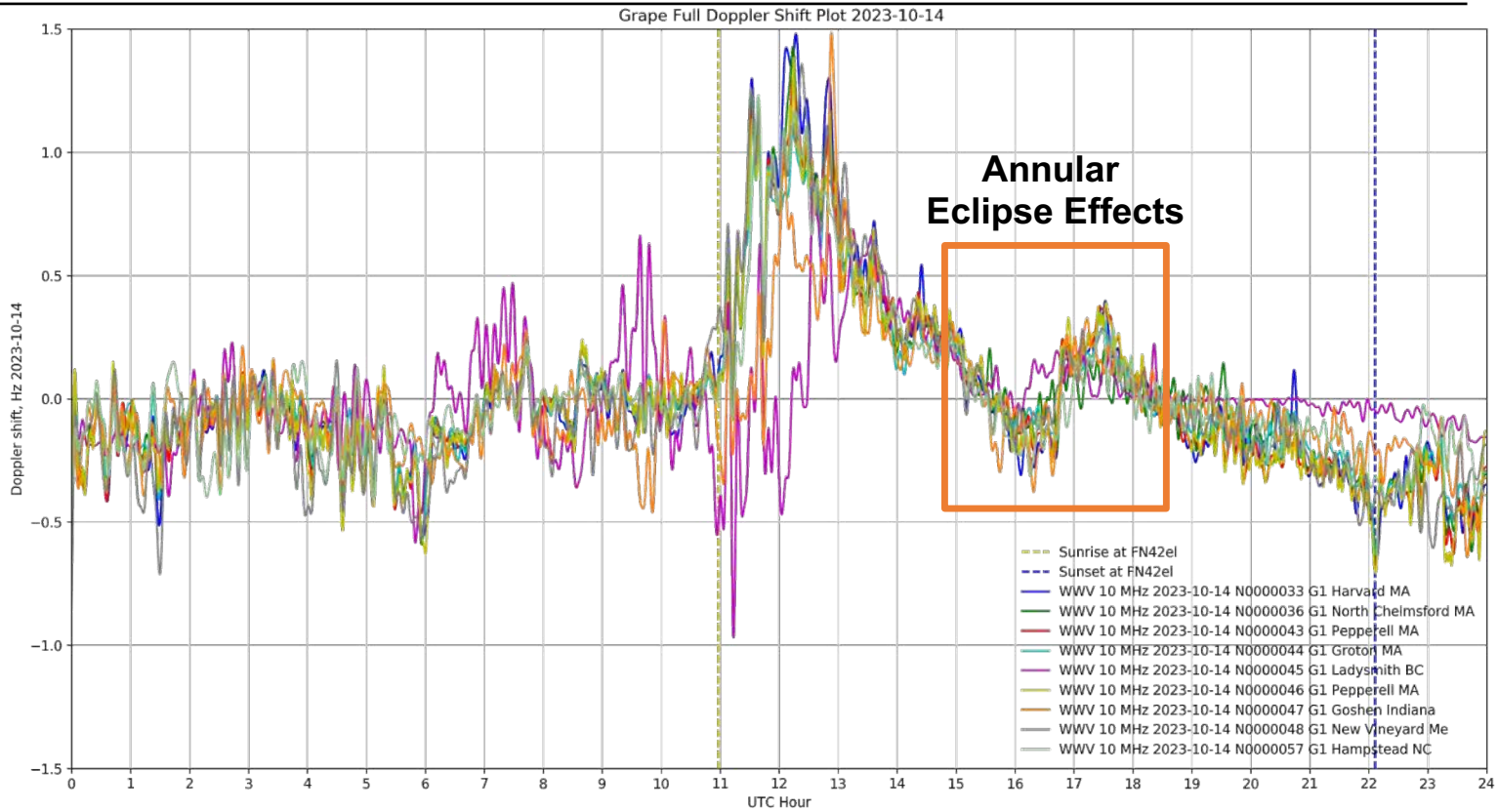
- All Grape1-DigitalRF Data is uploaded to the University of Alabama HamSCI Personal Space Weather Station Central Database server on a daily basis.
- Database is accessible from:
- psws.hamsci.org
- pswsnetwork.caps.ua.edu
- Green points in this figure show actively reporting stations on 12 Dec 2023
- Over 30 Grape1-DRFs provided observations for the 14 Oct 2023 annular eclipse

HamSCI PSWS Network

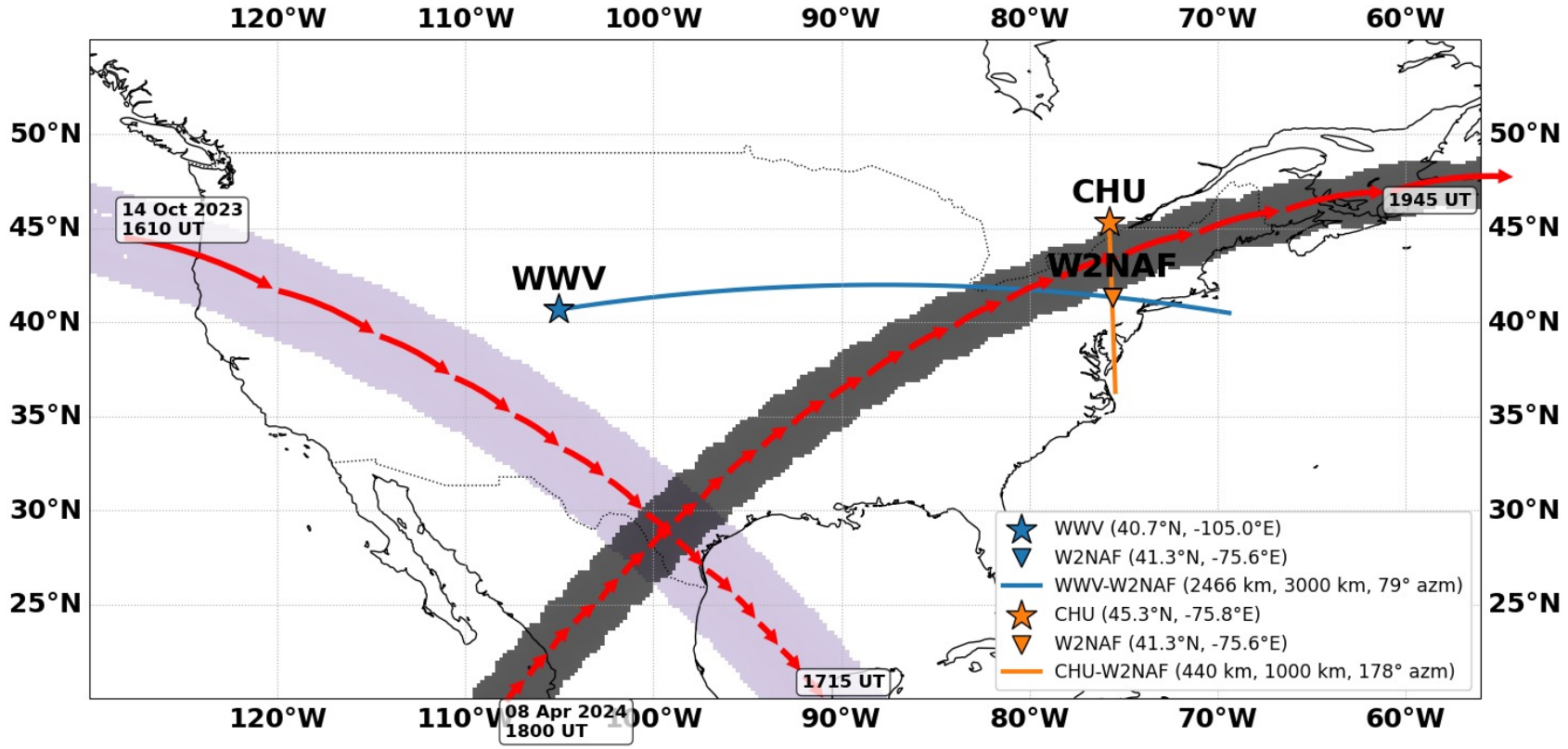


New England Grape Group
October 14, 2023 WWV 10 MHz Doppler

- There is still a legacy Grape1-FLDigi network in operation across the United States.
- These are Grape1-FLDigi Observations of the 14 October 2023 eclipse from the New England Grape Group.



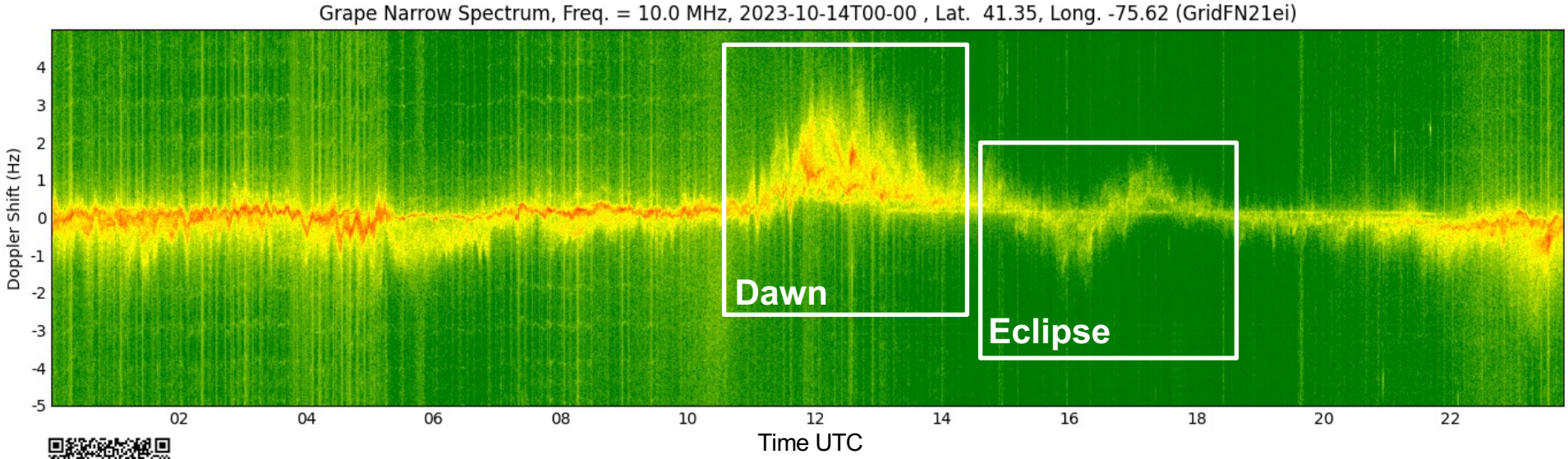
WWV-CHU-W2NAF



W2NAF 10 MHz Grape1-DRF WWV Doppler

October 14, 2023 Annular Eclipse

W2NAF Receiver near Scranton, PA



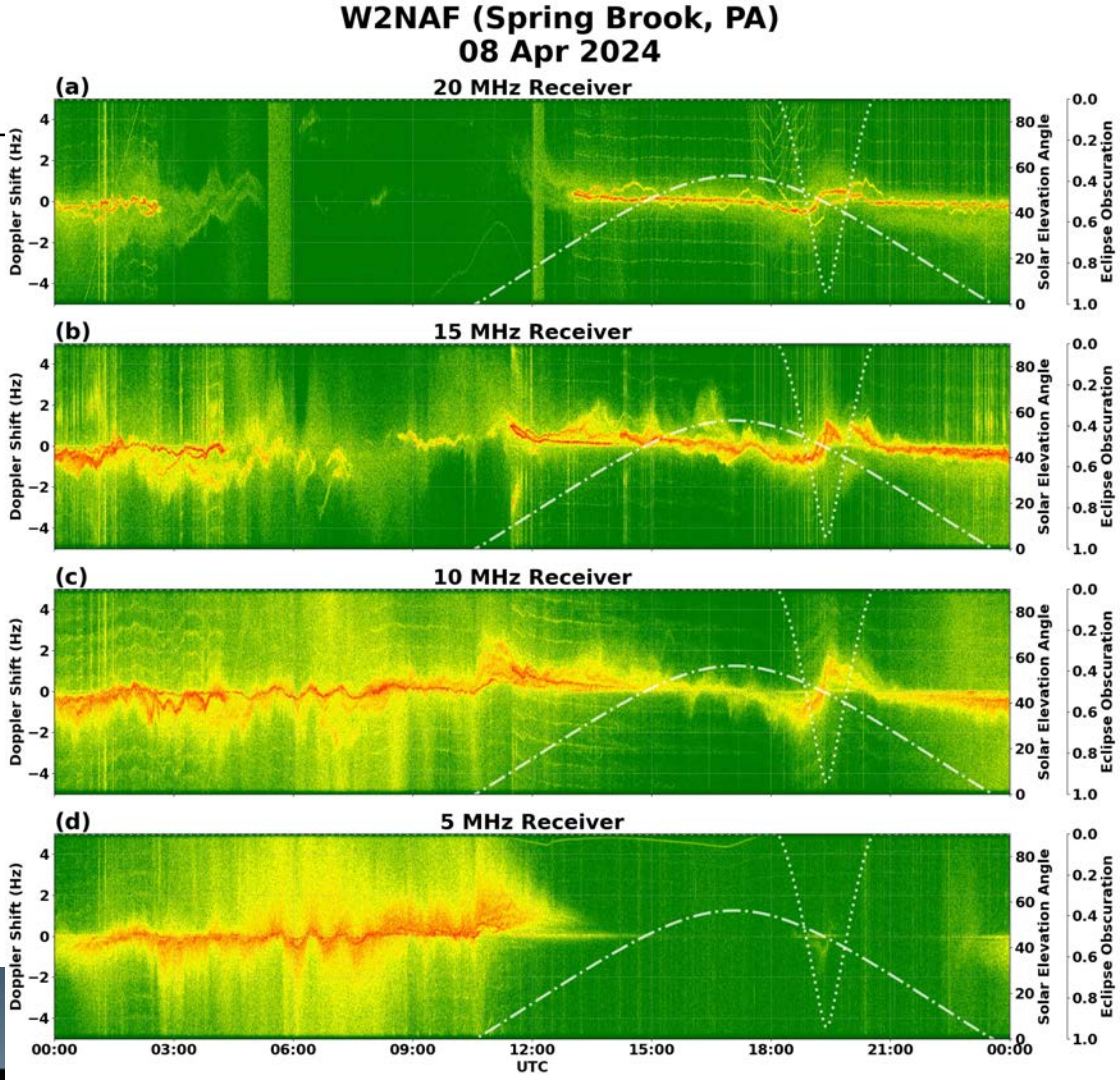
See all Grape1-DRF October 14, 2023 Annular Eclipse Summary Plots

https://livescranton-my.sharepoint.com/:f:/g/personal/nathaniel_frissell_scranton_edu/Eus-k84rsMtJrhL_lKHvL9EBjGxHRK752MWkM-uk-RNVQg?e=7w8Xga

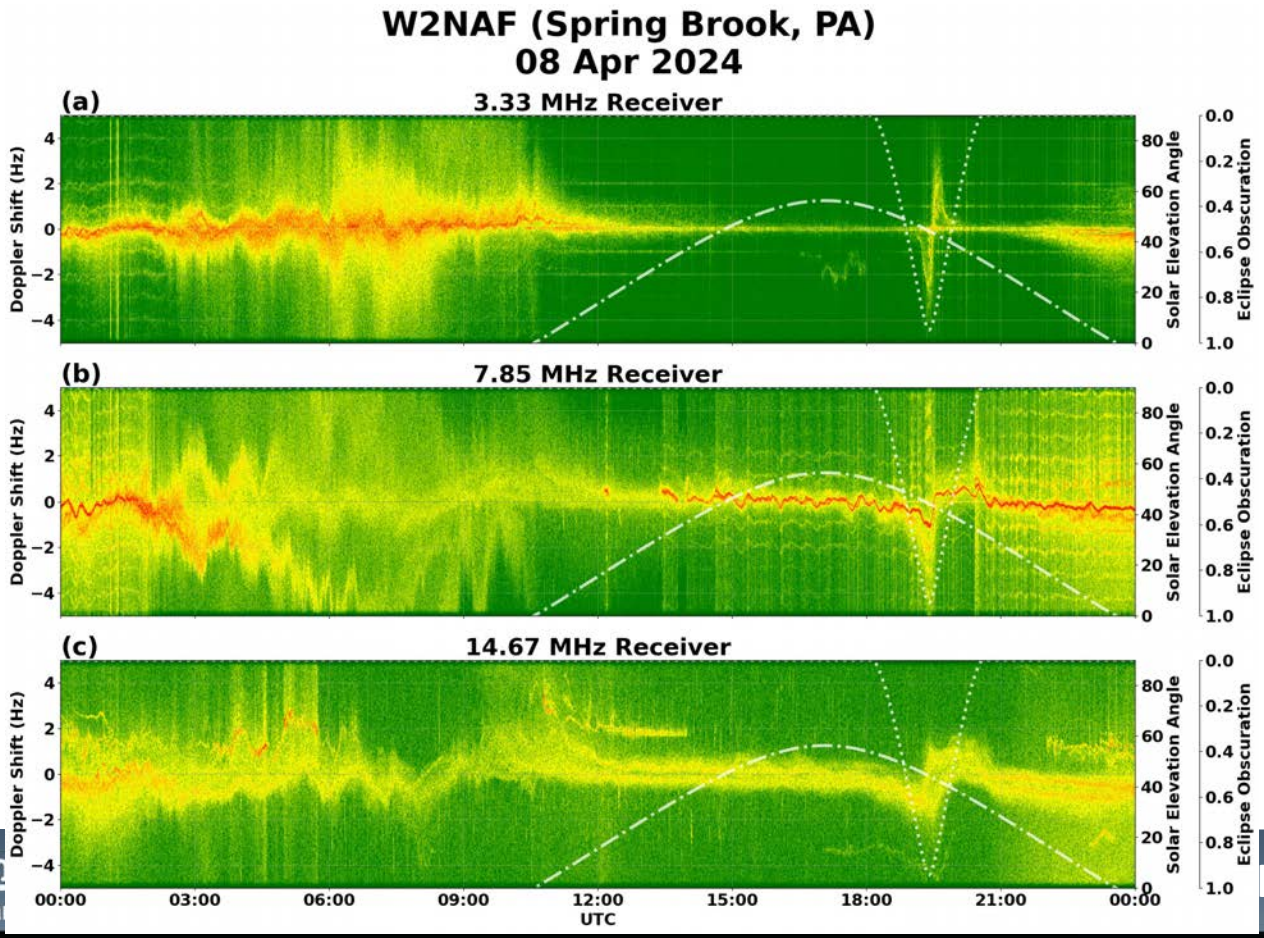
WWV → W2NAF

8 April 2024

HF Doppler



CHU → W2NAF 8 April 2024 HF Doppler



Whistler Catcher VLF Receiver

Developed by Jonathan Rizzo KC3EEY

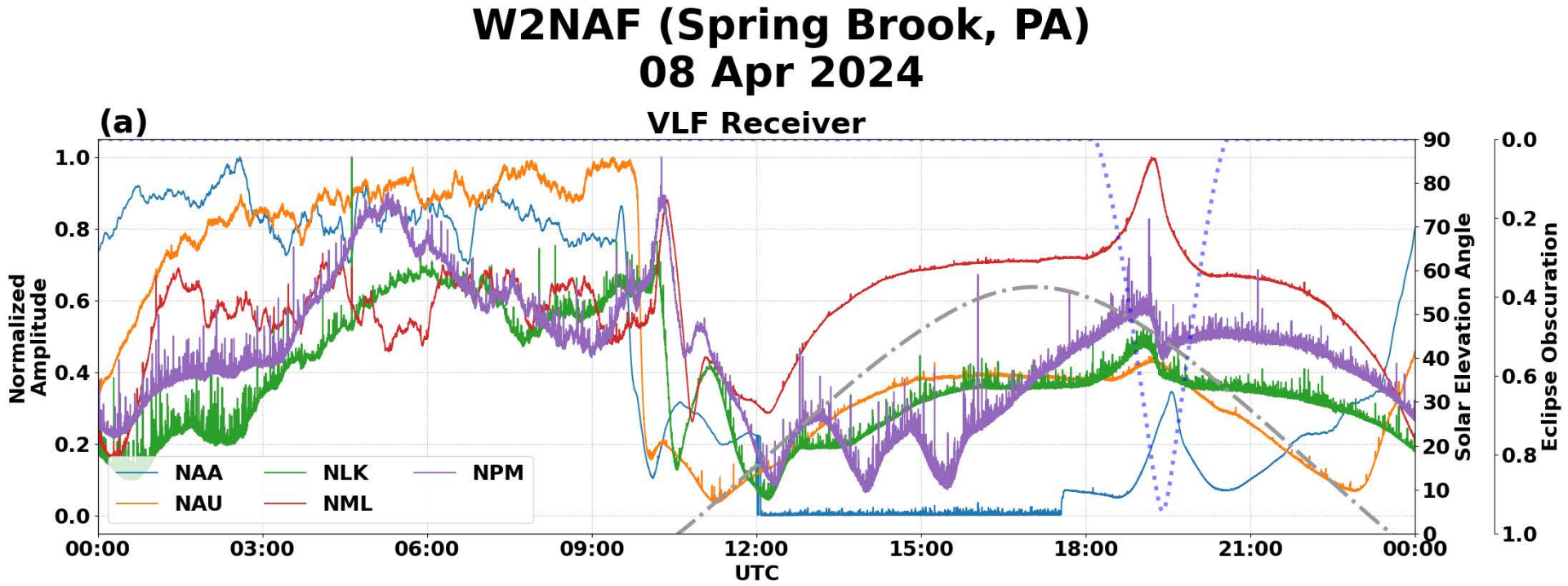
Purpose

- A 4-channel VLF SDR module to record the VLF spectrum up to 100 kHz for purposes of capturing Natural Radio emissions, Sudden Ionospheric Disturbances in VLF transmitters, and VLF amateur transmissions.

Features

- Uses the Texas Instruments TLV320ADC6140: Quad-channel 768-kHz Burr-Brown™ audio analog-to-digital converter
- Up to a 384 kHz sample rate, 112 dB dynamic range
- Clocking provided by SynthDO module
- 4-channel input
- Outputs spectrum in a vlfrx-tools-compatible stream.

W2NAF/KC3EEY VLF Receiver 8 April 2024



WSPRDaemon
HF Doppler

http://wsprdaemon.org/technical.html

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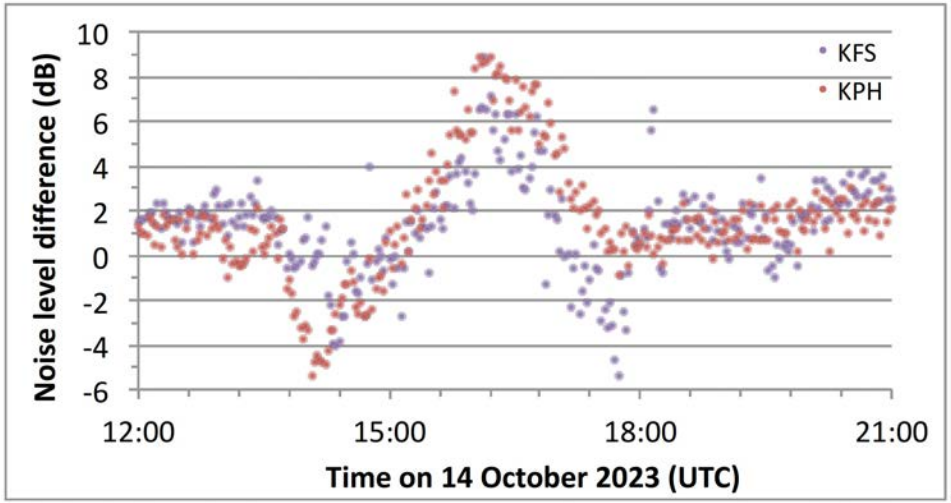
WSPRDaemon Observations

- WSPRDaemon is an advanced WSPR decoder developed by Rob Robinett AI6VN, Gwyn Griffiths G3ZIL, et al.
- Unlike the standard WSPR decoder, WSPRDaemon can
  - Measure Noise
  - Derive true signal strength from SNR and measured noise
  - Use GNSS-disciplined receivers to measure Doppler spread on FST4W spots
- FST4W is a 4-GFSK amateur radio digital protocol designed particularly for the LF and MF bands, for quasi-beacon transmissions of WSPR-style messages.

http://wsprdaemon.org/technical.html

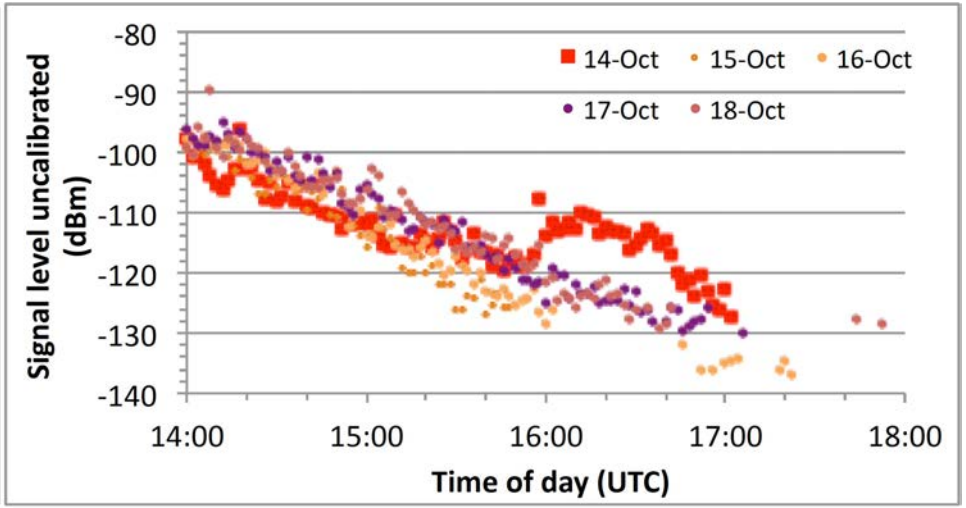
Preview of FST4W 2023 Annular Eclipse Observations

Noise Level at 7.040 MHz



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 Level at 3.570 MHz

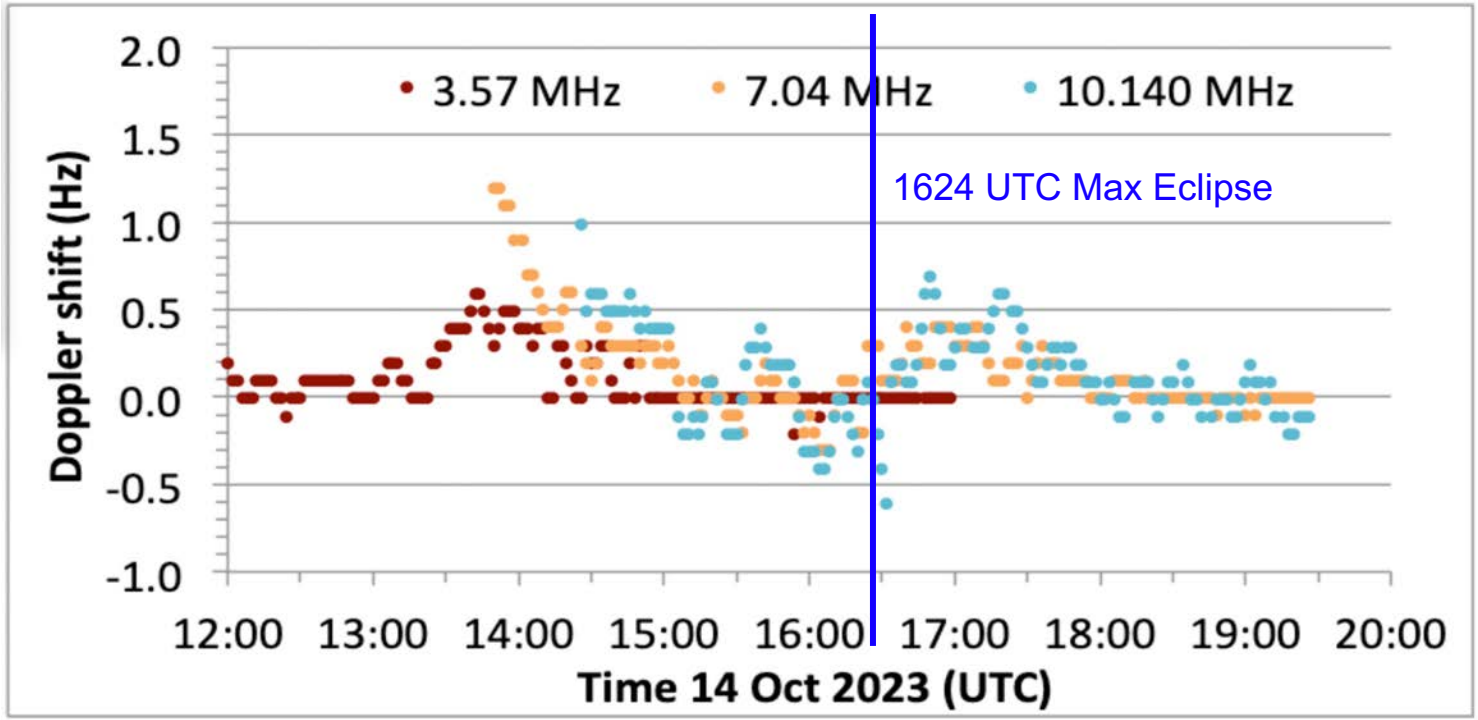


Signal levels on 14-18 October 2023 at KA7OEI-1 for FST4W transmissions from WO7I on 3.57 MHz.

Turn Island Systems WSPRSonde-8

- The WS-8, with the Six-Band Filter / Combiner (80 / 40 / 30 / 20 / 15 / 10 meter bands)
- A Bodnar GPSDO provides the 10 MHz reference clock
- GPS input via common puck antenna (or other type)
- The WS-8 includes a passive antenna splitter, which lets the GPSDO share the antenna
- USB connection for configuration, monitoring, and program updates, not required for operation
- +12VDC (2A) power input

Preview of FST4W 2023 Annular Eclipse Observations



Doppler shift at three frequencies from simultaneous transmissions from WO7I to ND7M. 3.5 MHz was open during the night, 7 MHz, then 10 MHz, opened as the F2 layer critical frequency rose after dawn.

HamSCI Solar Eclipse Time Difference of Arrival (TDOA) Experiment Preliminary Results

Steve Cerwin WA5FRF
Paul Bilberry N5DUP
Sam Blackshear AB5YO
Nathaniel Frissell W2NAF
Tom McMahan K1FR
Alexandros Papadopoulos KC3WUD

May 15, 2024

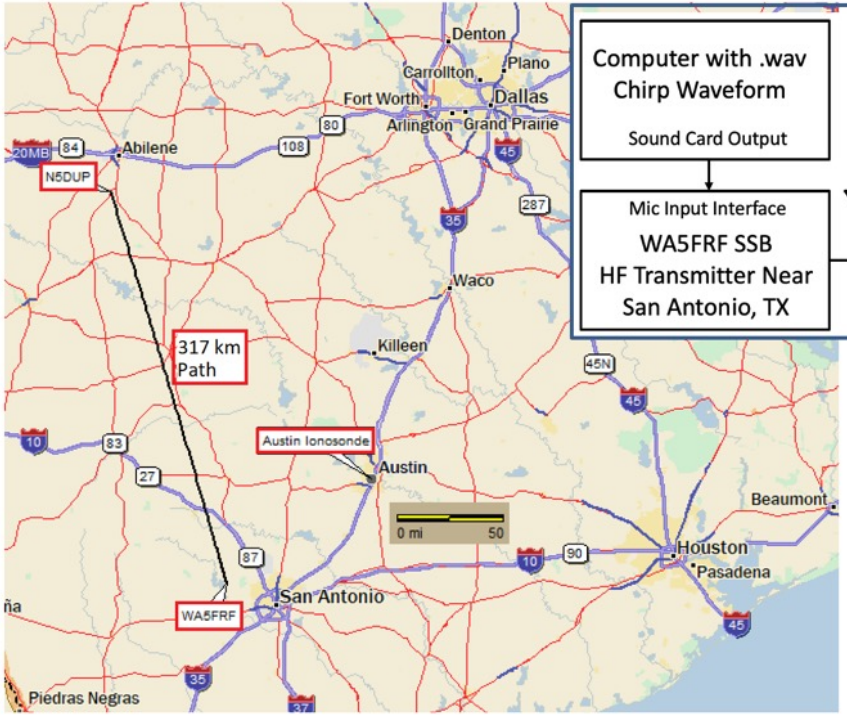
https://hamsci.org/eclipse-tdoa

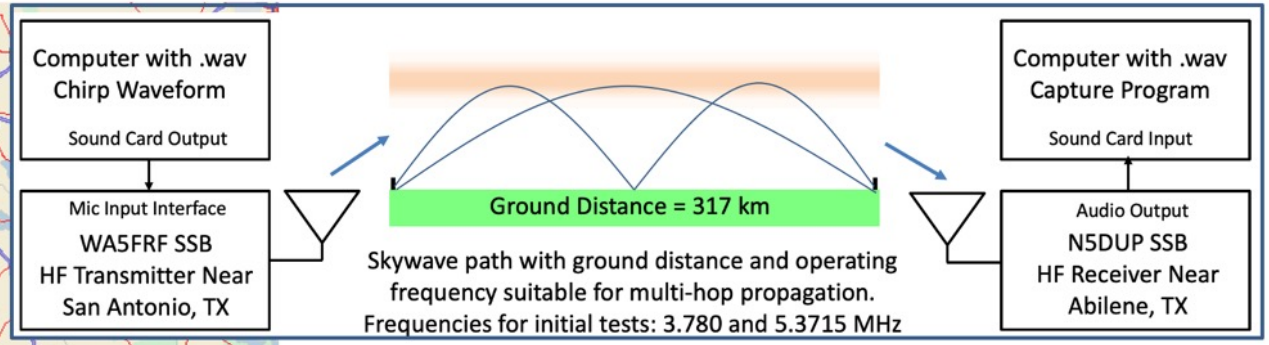
Solar Eclipse TDOA Experiment

- The layer height between two radio stations could be deduced from a Time of Flight (TOF) measurement but doing so would require precision absolute time references and other expensive equipment that are beyond the capabilities of most radio amateurs.
- However, by analyzing multipath signatures of a chirp waveform, it is possible to get relative path length measurements even without GPSDO.
- In the Eclipse TDOA Experiment, we ask pairs of stations to team up in small groups to systematically transmit and receive customized chirp waveforms to make these measurements.

Steve Cerwin WA5FRF is leading the Eclipse TDOA Experiment

Geographic Layout TDOA Verification Experiment





Geometry and Setup for Initial TDOA On-Air Experiments Using Amateur Radio Stations WA5FRF and N5DUP

Geometry is convenient for proximity to expected eclipse Path and to the Austin Ionosonde for ground truth data.

The 60 m and 75 m frequency bands were chosen for likelihood of both 1 hop and 2 hop propagation.

Audio Chirp to Measure Multipath TDOA

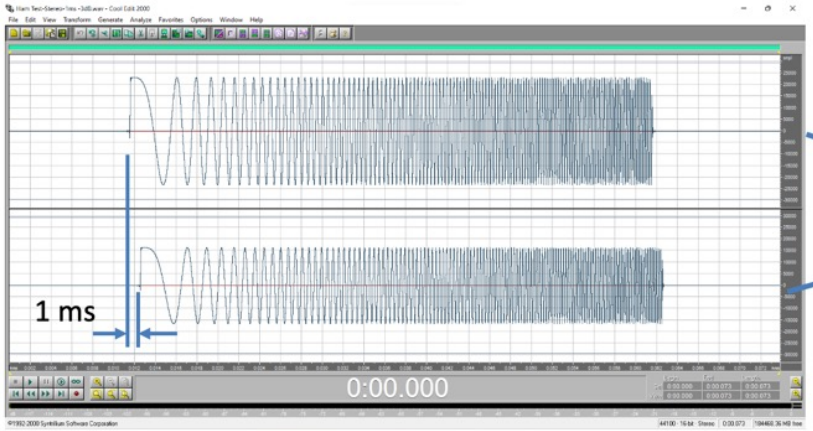


Fig 2a. Two 100 Hz/ms Chirps with 1 ms Time Delay. Delayed Chirp is 3 dB lower in Amplitude.

SUM

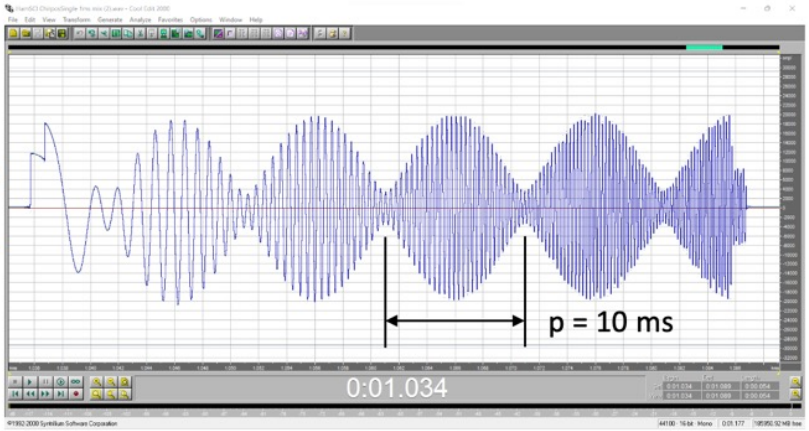


Fig 2b. Summation produces a Waveform with a Beat Note of Period p = 10 ms.

Summation of a linear chirp with a delayed copy of itself produces a difference frequency at Δf = Sweep Rate * Δt. Beat pattern has a period p = $1/\Delta f$. The Time Difference of Arrival (TDOA) can be calculated by:

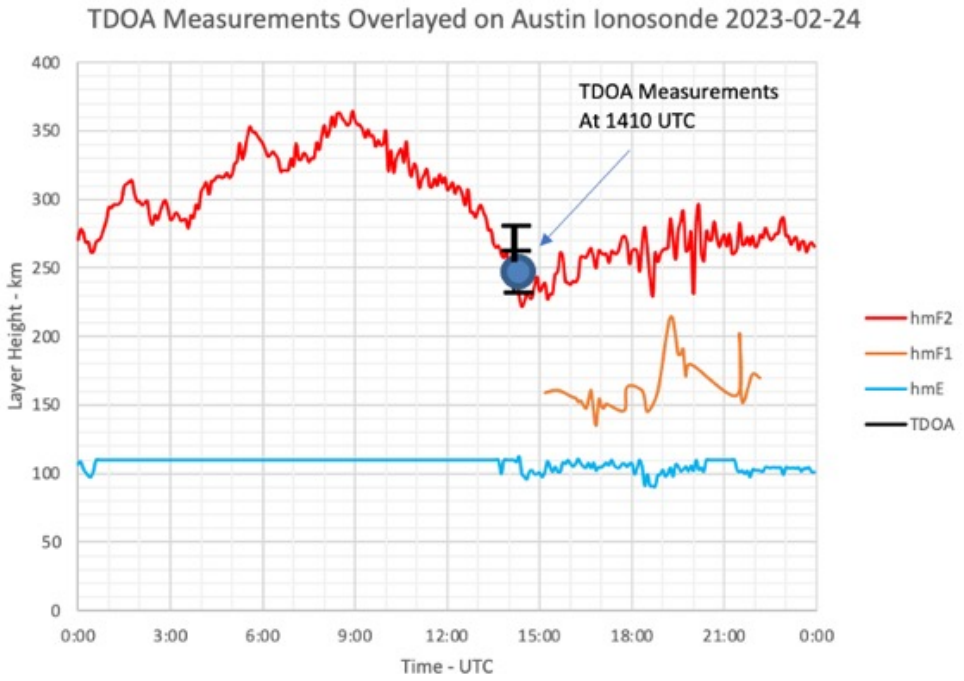
TDOA = 1/(p*Sweep Rate)

Example: two 100 Hz/ms chirps 1ms apart produce a difference frequency of 100Hz, which has a period of 10 ms.

TDOA = 1/(10 ms * 100 Hz/ms) = 1 s/1000 = 1 ms

HF TDOA Results and Future Work

- Pre-eclipse test shows good agreement with ionosonde hmF2.
- Measurements taken every 15 minutes for 8 hours day of the Annular eclipse.
- Scranton DSP students now working with Steve Cerwin and Nathaniel Frissell to analyze eclipse measurements as part of course project.
- Will repeat experiment during April 2024 eclipse.



Error bars show range of 18 separate measurements using short pulses and 10-50 Hz/ms chirps.

Preliminary Results

- Initial analyses have been performed on a 9 km NVIS and a 317 km regional path in Texas. The NVIS path was directly within the path of totality.
- There was good agreement between F2 layer height measured by TDOA analysis and hmF2 data reported by the Austin ionosonde.
- Height bumps in the F2 layer were observed in both paths at times corresponding to local eclipse passage.
- Complexity and turbulence observed in the data:
  - Greater incidence of low TDOA values suggests greater E layer involvement than in data sets from previous years
  - Rapidly changing band conditions observed within the 8-second time span required to send 10 chirps and even within a single 0.75 second chirp
  - Analyses have shown the presence of differential Doppler shifts in the chirp data.

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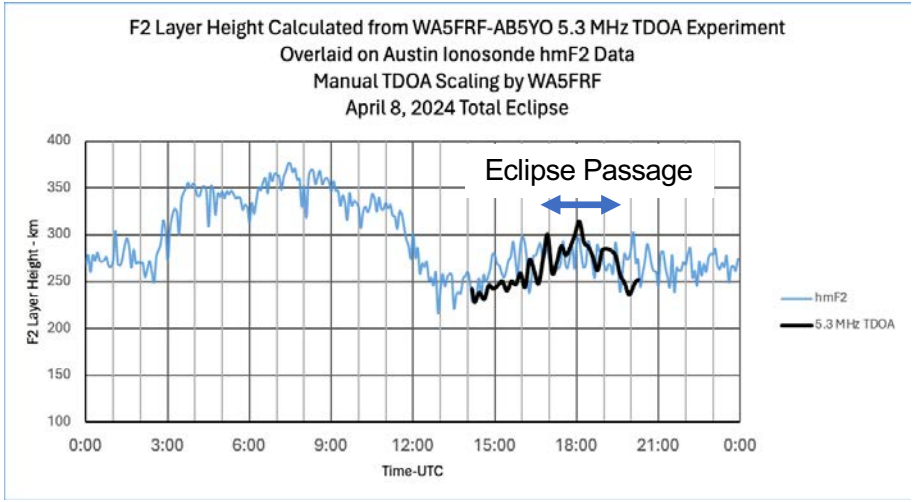
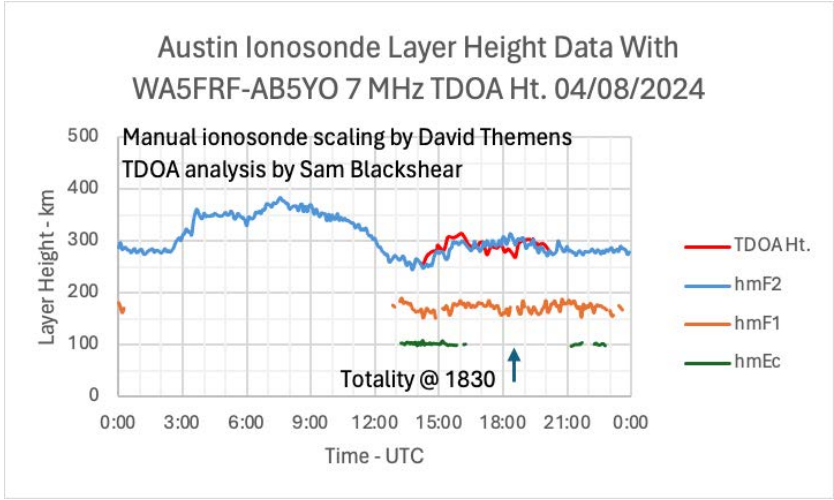
Results of WA5FRF-AB5YO NVIS Path Using Beat Note Analysis Overlaid on Austin Ionosonde hmF2



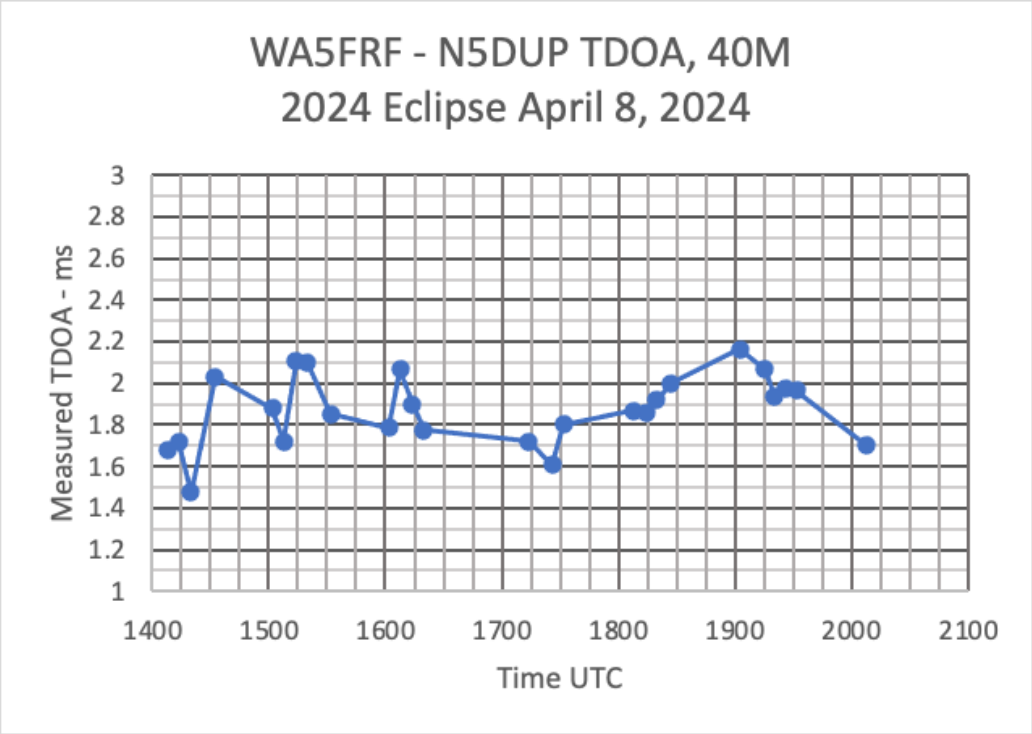
60-meter TDOA data agreed well with Austin ionosonde hmF2 and showed a height bump near the time of eclipse passage in Texas.



40-meter TDOA data agreed well with Austin ionosonde hmF2 but did not show a height bump.

Both data sets were analyzed manually by selecting the chirp with cleanest modulation appearance out of each 10-chirp set and extracting the period of the beat note by measuring the time delay between nulls in the pattern.
60-meter data analyzed by Steve Cerwin WA5FRF; 40-meter data analyzed by Sam Blackshear AB5YO

Preliminary Results of WA5FRF-N5DUP 317 km Path Analyzed by Autocorrelation



Correlation analyses under investigation include correlation of the received waveform with a transmitted reference and correlation with itself (autocorrelation). This autocorrelation analysis was performed by Tom McMahan K1FR.

Transmit:
WA5FRF near San Antonio, TX
EL09mm 29.963, -98.875
Receive:
N5DUP near Abilene, TX
EM02ch 32.313, -99.792

Both the 60-meter and 40-meter data sets showed height bumps at eclipse passage time.

Eclipse Day Solar-Terrestrial Data

Provided by Paul Bilberry N5DUP

Solar Indices Apr 8, 2024

Show no energetic events that would have affected the ionosphere

A. Energetic Events

```
Begin  Max  End  Rgn   Loc   Xray  Op 245MHz 10cm   Sweep
None
```

B. Proton Events

None.

C. Geomagnetic Activity Summary

The geomagnetic field was quiet.

D. Stratwarm

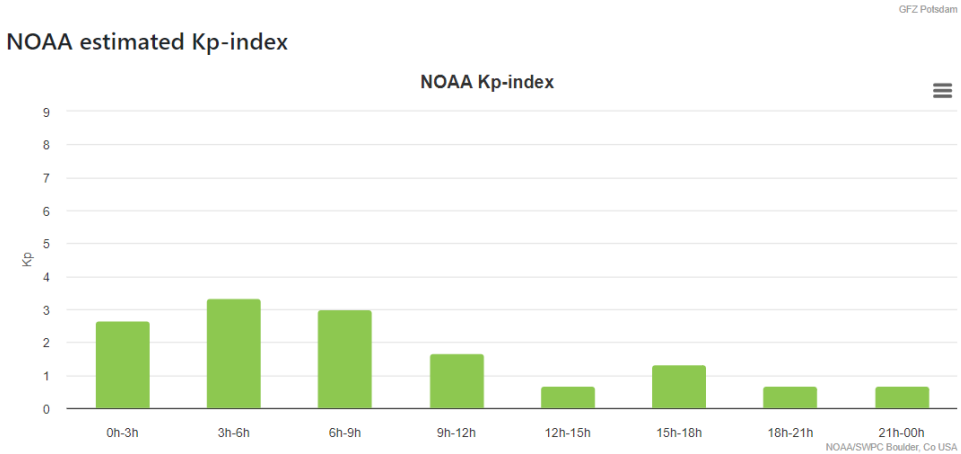
Not available

E. Daily Indices: (real-time preliminary/estimated values)

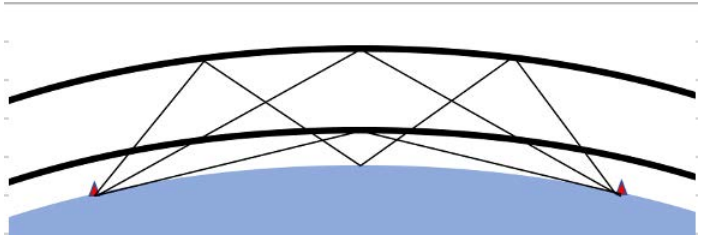
```
10 cm 125  SSN 079  Afr/Ap 005/005   X-ray Background B3.5
Daily Proton Fluence (flux accumulation over 24 hrs)
GT 1 MeV 9.4e+04   GT 10 MeV 1.6e+04 p/(cm2-ster-day)
(GOES-18 satellite synchronous orbit W137 degrees)
Daily Electron Fluence
GT 2 MeV 1.10e+07 e/(cm2-ster-day)
(GOES-16 satellite synchronous orbit W75 degrees)
3 Hour K-indices
Boulder 2 1 1 1 2 2 1 1 Planetary 2 2 0 1 2 1 2 1
```

K-Planetary Apr 8, 2024

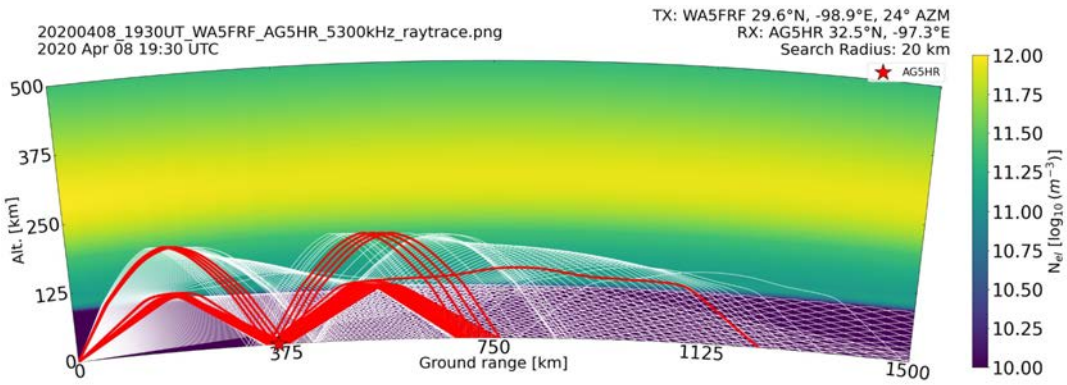
Real-time sample shows that K_p during the eclipse were very low suggesting that any change in radio wave propagation and layer height before, during and after the eclipse were not caused be a geomagnetic event from an earth directed CME.



Possible Multipath Modes Include Multiple Hops from E and F Layers and Simultaneous E-F Layer



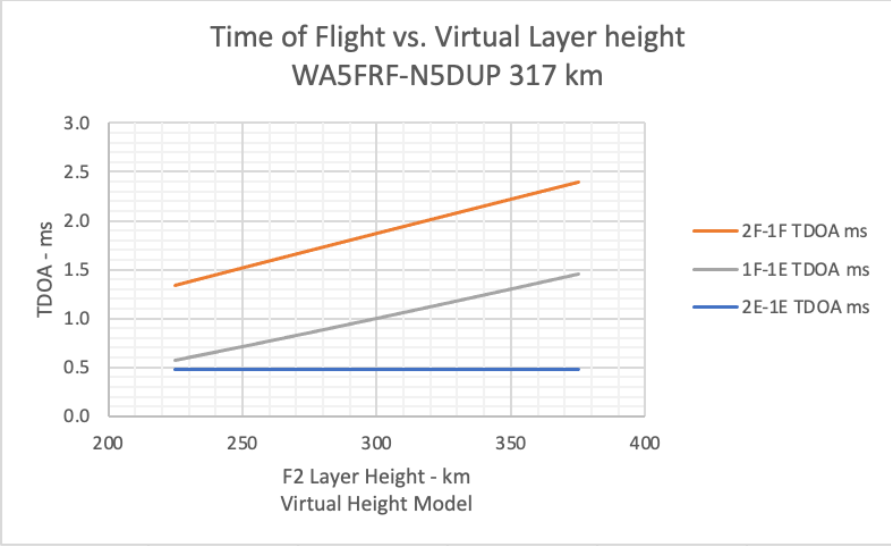
The multipath mode previously observed over paths less than 1500 km showed timing consistent with 1 and 2 hops from the F2 layer. However other paths are possible, especially at this high part of the sunspot cycle.

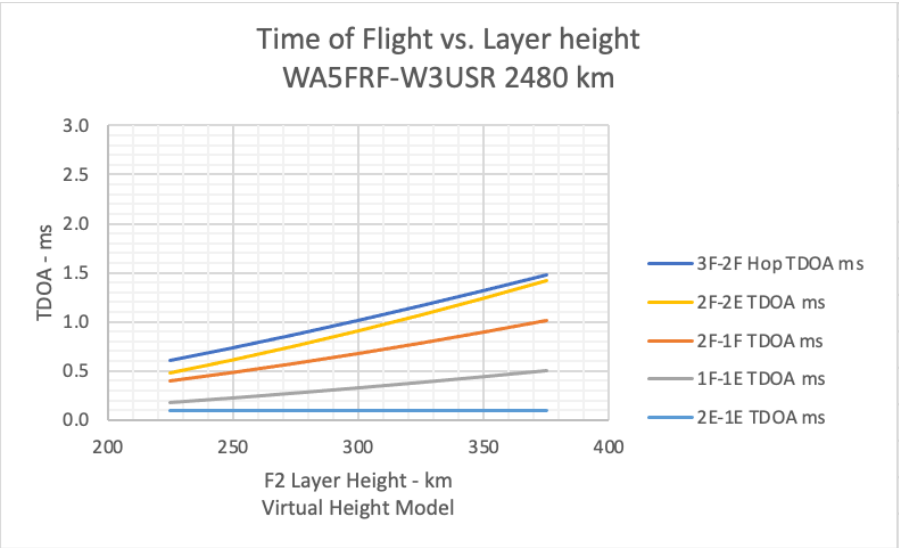


Preliminary ray trace analysis shows simultaneous E and F layer propagation was possible over a 360 km path on eclipse day.

Modes involving the F2 layer are preferred for eclipse studies because it has been observed to exhibit significant height changes with changing solar radiation. Ionosonde data shows the mostly daytime E and F1 layers change little in height over the course of a day.

Predicted TDOA Times for Various Modes at Ground Distances of 317 km and 2480 km





Naming convention: preceding number is the number of hops and letter is layer. E.g., 2F-1F is multipath between 1 and 2 hops from the F layer. 1F-1E is multipath between 1 hop from the F layer and 1 hop from the E layer. This data was calculated using a virtual height model corrected for the curvature of the earth. The E layer was assumed to be invariant at 105 km. Note TDOAs get smaller with increasing ground distance.

HF TDOA Summary

- The Initial analyses on the WA5FRF-AB5YO 9 km NVIS and WA5FRF-N5DUP 317 km paths in Texas have been encouraging and show very interesting complexity.
- There was good agreement between F2 layer height measured by TDOA analyses and hmF2 data reported by the Austin ionosonde.
- Height bumps were observed at the time of eclipse passage in Texas suggesting a momentary rise and fall in F2 layer height. The S-shape Doppler data acquired by the Grape receiver network is consistent with a height bump.
- Multipath complexity and apparent turbulence has been observed in the data that have interesting analysis implications. These include:
  - Detections consistent with both the E and F1 layers.
  - Rapid TDOA changes observed within the 10-chirp, 8-second transmission time.
  - Doppler effects within individual chirps that complicate analyses but offer unique insights.
- The inclusion of refractive ray trace analyses will help with multipath identification and is planned.
- Development of automated data analysis methods is underway and will help tremendously in decoding more of the data.

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Medium Wave (MW) AM Broadcast Recording Experiment

https://hamsci.org/eclipse-am

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AM Broadcast Receive Experiment

- **Regular AM Broadcast Radio** operates in the Medium Wave (MW) band from 530-1700 kHz.
- **At night, MW AM can propagate hundreds to thousands miles** via E/F-region refraction when D-region absorption is reduced.
- **Eclipse effects** can also be observed.
- **Ruth Bamford** used citizen science reports of MW AM during the 1999 UK Total Solar Eclipse. See https://doi.org/10.48550/arXiv.1703.01491.
- **Nick Hall-Patch VE7DXR** is coordinating a similar MW AM experiment for the 2023/2024 HamSCI FoEIS.

https://hamsci.org/eclipse-am

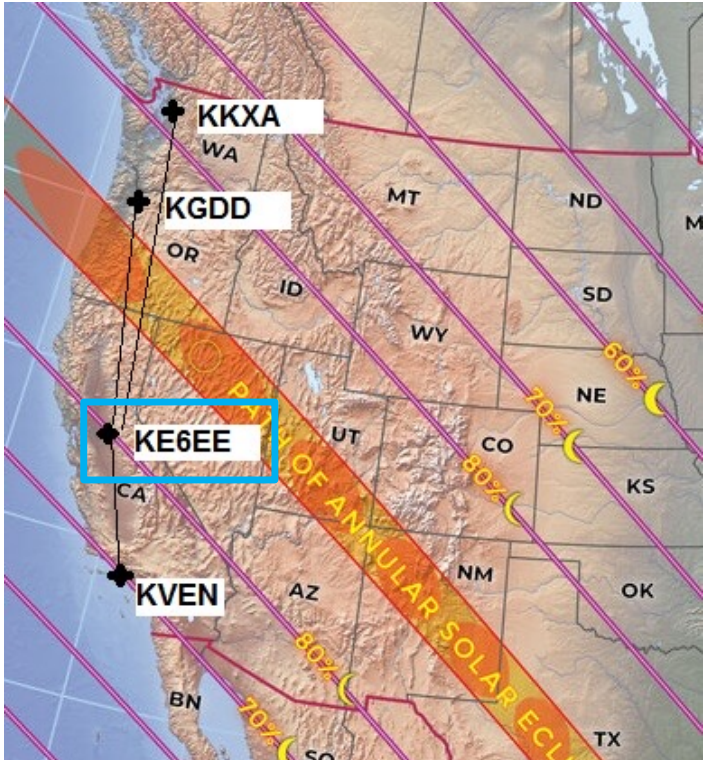
Antenna mast of AM radio station in North Carolina.
Photo by Ildar Sagdejev.
https://commons.wikimedia.org/wiki/File:2008-07-28_Mast_radiator.jpg

October 2023 AM Results

- During the 14 October 2023 annular solar eclipse, Richard Cook, KE6EE, near Sacramento, CA, recorded the entire AM broadcast band (530-1700 kHz) on his SDRplay Duo, a software defined radio.
- The recording included both the time period of the annular eclipse, 1505 to 1743 UTC (8:05 AM to 10:43 AM PDT) as well as the period during the ionospherically active period around local sunrise at 1413 UTC (7:13 AM PDT)
- Richard also recorded the same time period on 13 October 2023 to provide a comparison
- Carrier Sleuth software was used to visualize of the characteristics of AM broadcast station carriers on 1520kHz from the data he recorded on both days

MW AM Transmitter and Receiver Locations

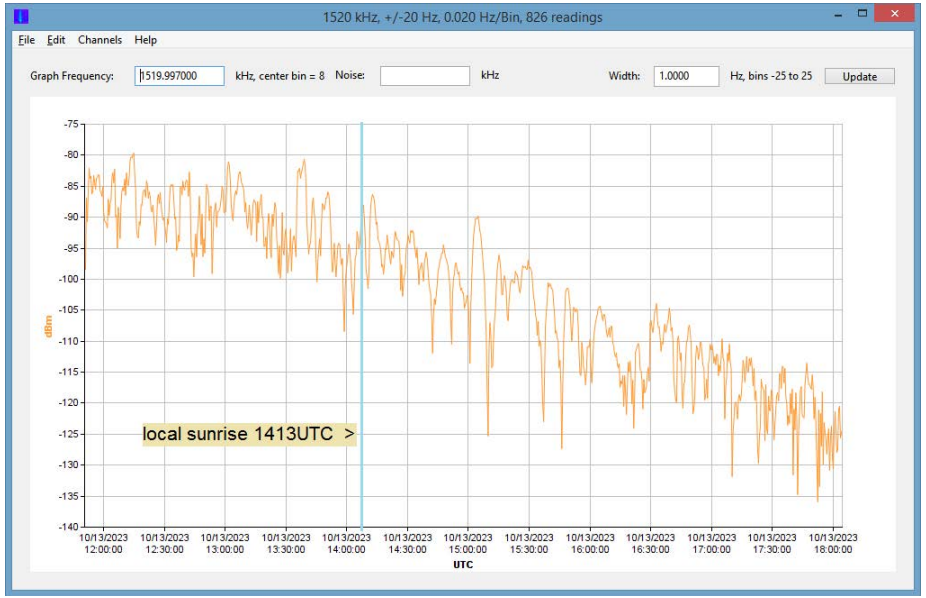
- The **KKXA**, **KGDD** transmitters and **KE6EE** receiver were all within the 80% obscuration zone, and the paths from transmitters to receiver **crossed the path of the eclipse**.
- The path from the **KVEN** transmitter to the **KE6EE** receiver **did not cross the path of the eclipse**, and KVEN was at 70% obscuration.



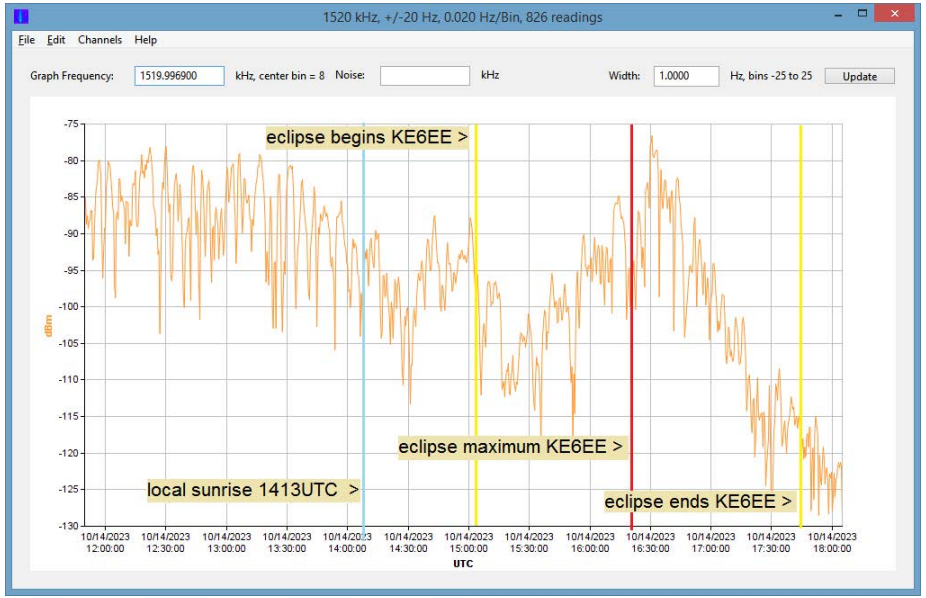
Derived from greatamericaneclipse.com graphic.

KKXA Signal Strengths on October 13 & 14, 2023

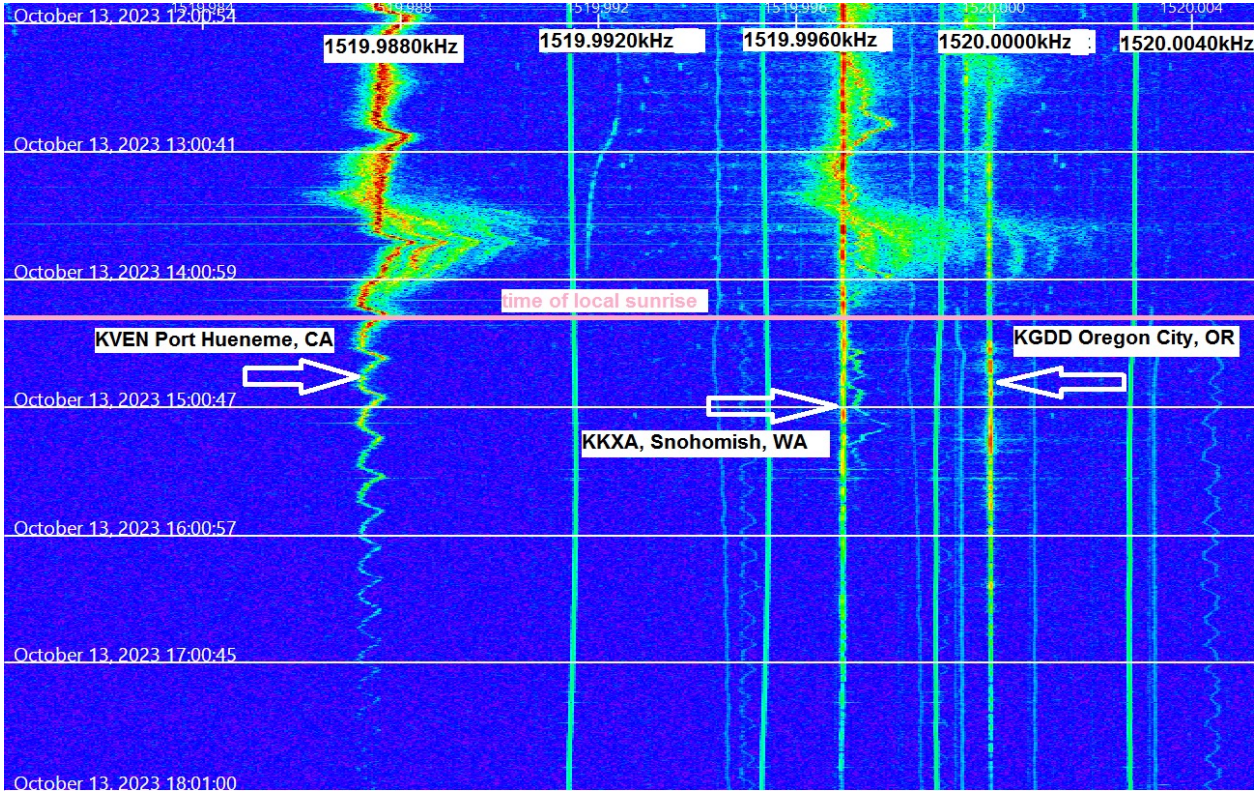
October 13 (NO Eclipse)



October 14 (Annular Eclipse)

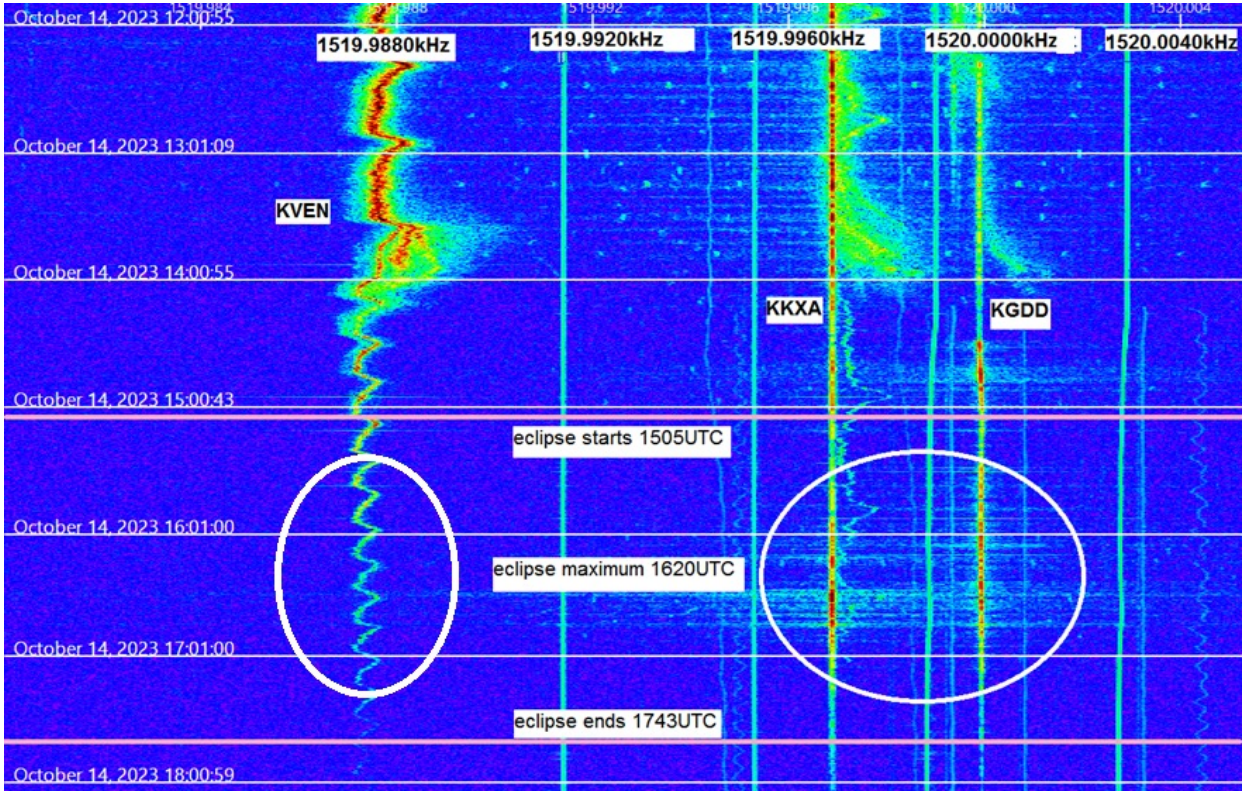


October 13, 2023 MW AM Observations



- Before local sunrise, carriers were shifted and spread out by the effect of the rising sun.
- Carrier strengths declined rapidly after local sunrise.
- KGDD's apparent rise in signal strength after sunrise was due to it having switched to higher day time power at 1430UT.

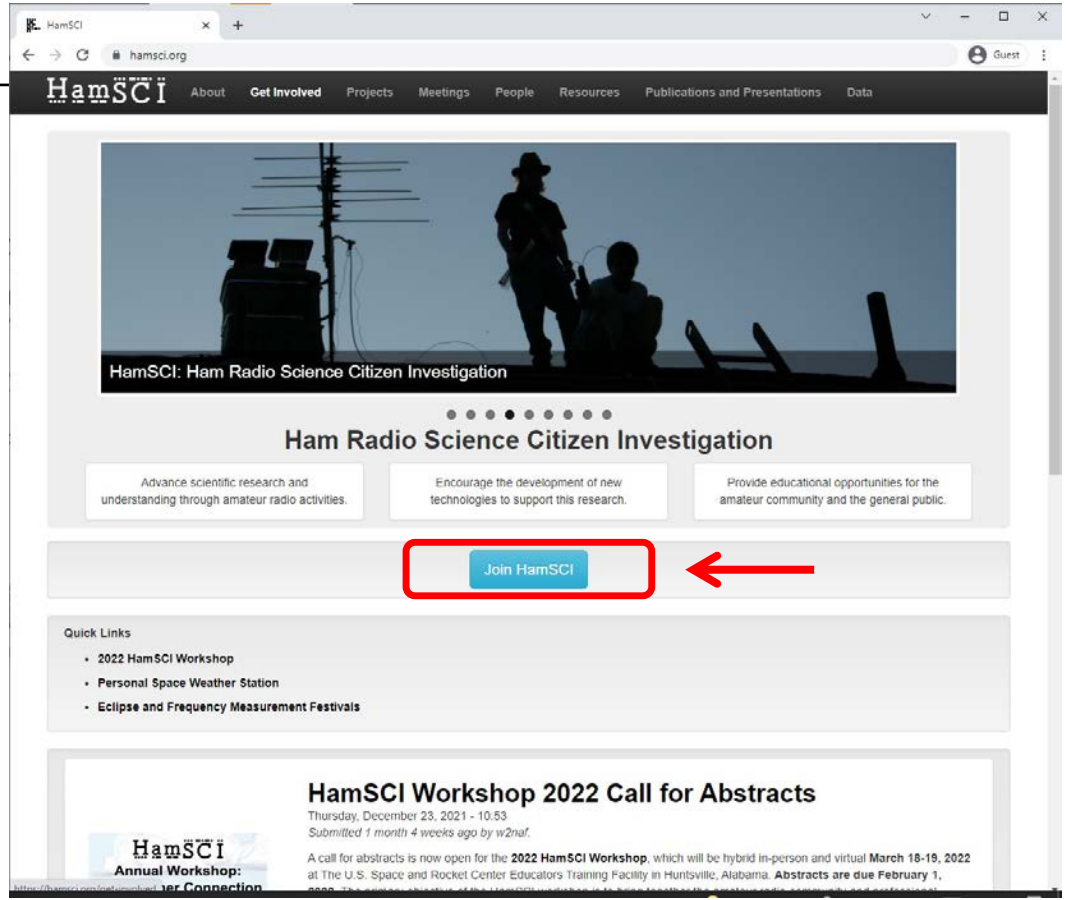
October 14, 2023 MW AM Observations



- KKXA and KGDD carrier strength increased and then decreased during the course of the eclipse.
- On October 13th, those signals had gradually faded away during that time period.
- However, there seemed to be no effect on the carrier strength of KVEN.

Getting Involved

- **HamSCI now has over 1200 members!**
- Join by visiting **hamsci.org**
- Main Google group is open discussion for all things related to HamSCI.
- Many specialized email lists and telecons, too!



Acknowledgments

We are especially grateful for the

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- 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 used in this paper, especially the 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).
- Ann Marie Rogalcheck-Frissell KC2KRQ for the HamSCI silhouette photograph.

Thank you from the HamSCI Community!

Visit the HamSCI Booth Hertz 5008
HamSCI Forum Today @ 3:55 PM in Forum Room 2!

Thank you!

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