HamSCI:
Space Weather
We Can Do Together

Nathaniel A. Frissell, Ph.D., W2NAF

Associate Professor, HamSCI Founder and Lead

Department of Physics and Engineering

The University of Scranton

Delaware Valley Radio Association

September 10, 2025

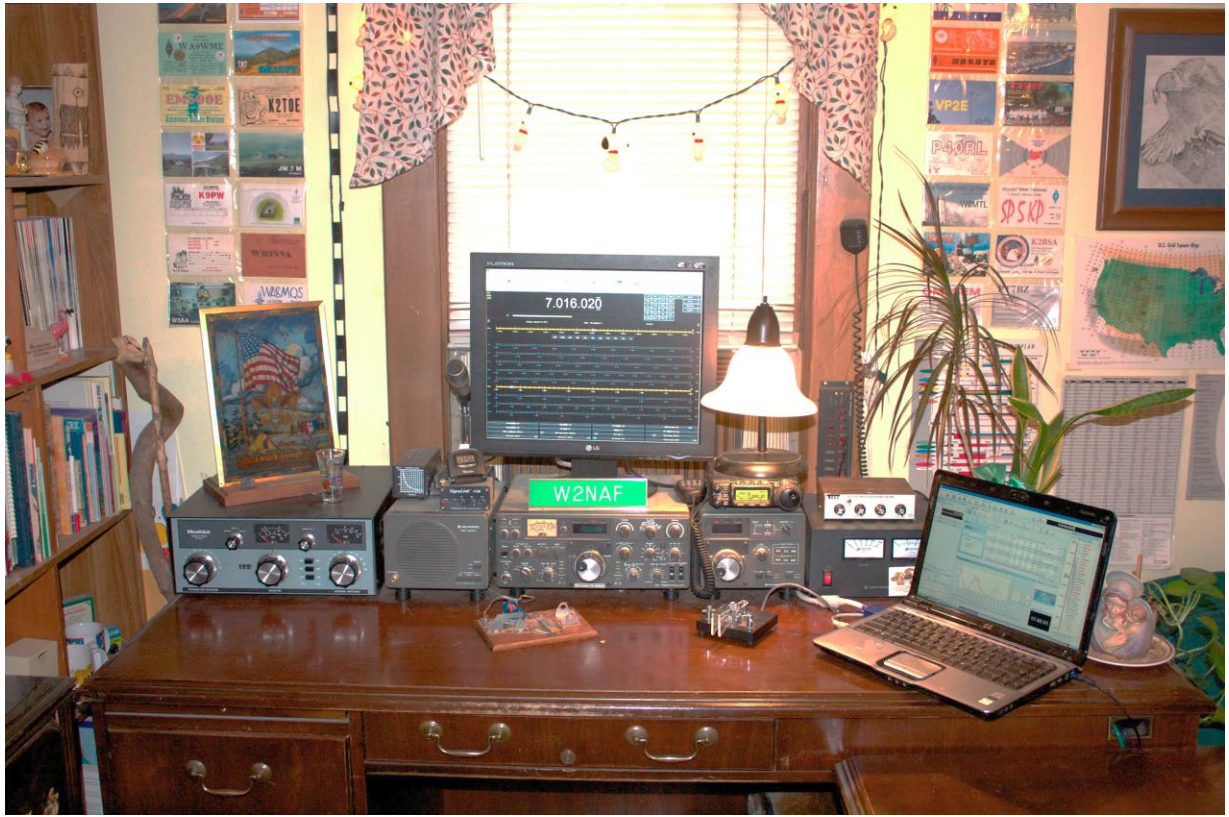
nathaniel.frissell@scranton.edu

Nathaniel Frissell, Ph.D., W2NAF

- **1998 – First Ham Radio License (KC2DXJ)**
- **2007 – BS Physics & Music Education**
  Montclair State University, Montclair, NJ
- **2015 – Started HamSCI**
- **2016 – MS, PhD Electrical Engineering**
  Virginia Tech, Blacksburg, VA
- **2016 – Post-Doc / Research Faculty**
  New Jersey Institute of Technology, Newark, NJ
- **2019 – Faculty @ University of Scranton**
  The University of Scranton, Scranton, PA
- **Spent time researching (and ham radio operating!) in Svalbard, McMurdo Station, and Adak Island.**

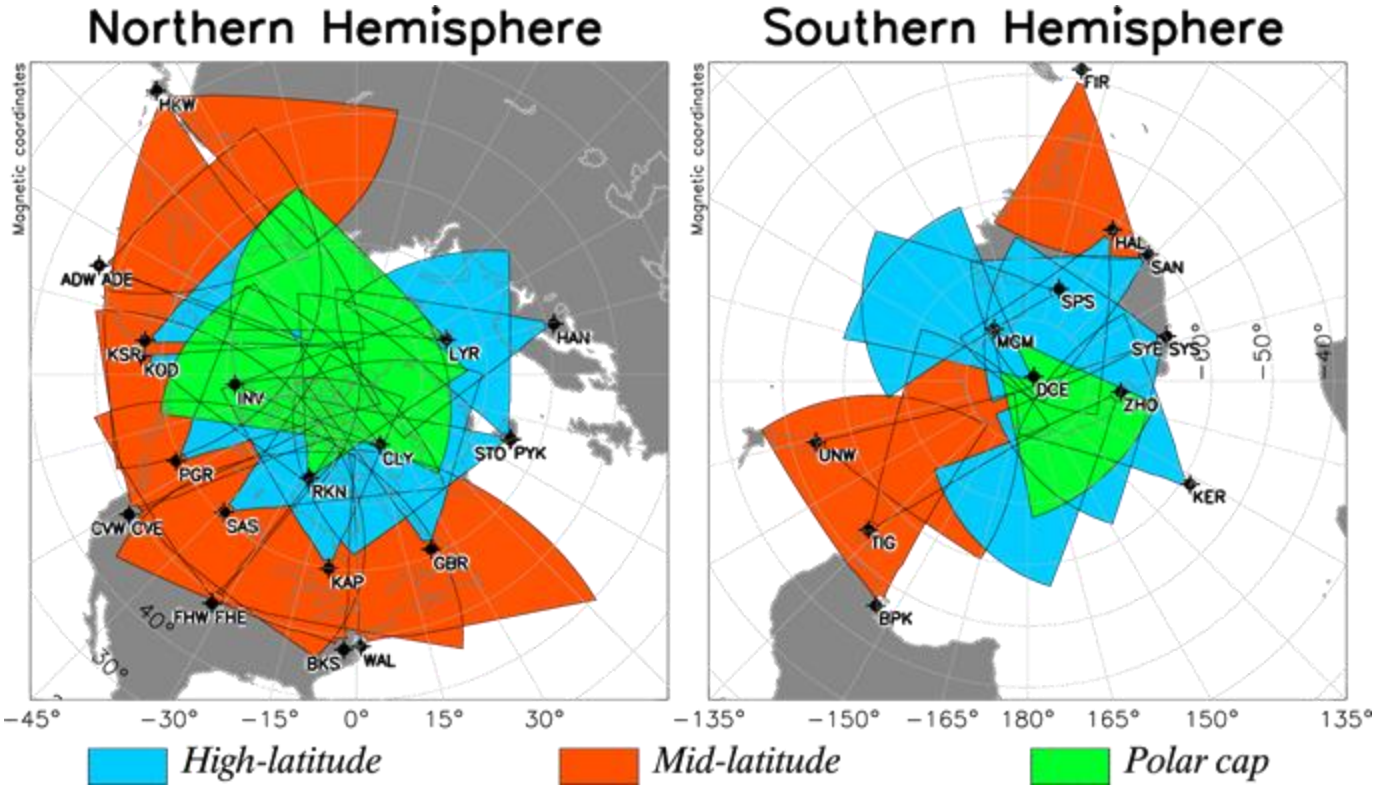
nathaniel.frissell@scranton.edu

W2NAF Station c.a. 2005



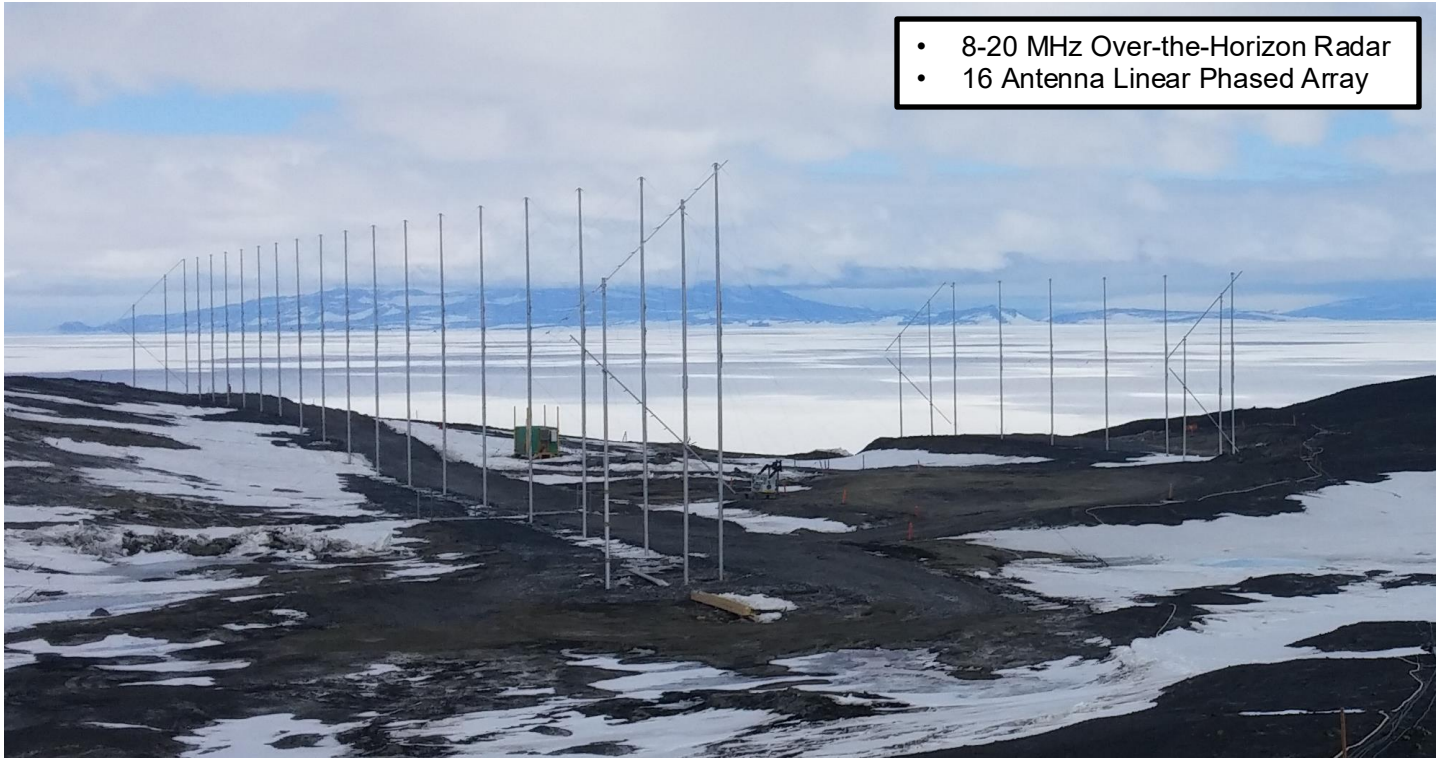
nathaniel.frissell@scranton.edu

Super Dual Auroral Radar Network



[http://vt.superdarn.org, 15 Sept 2018]

Super Dual Auroral Radar Network



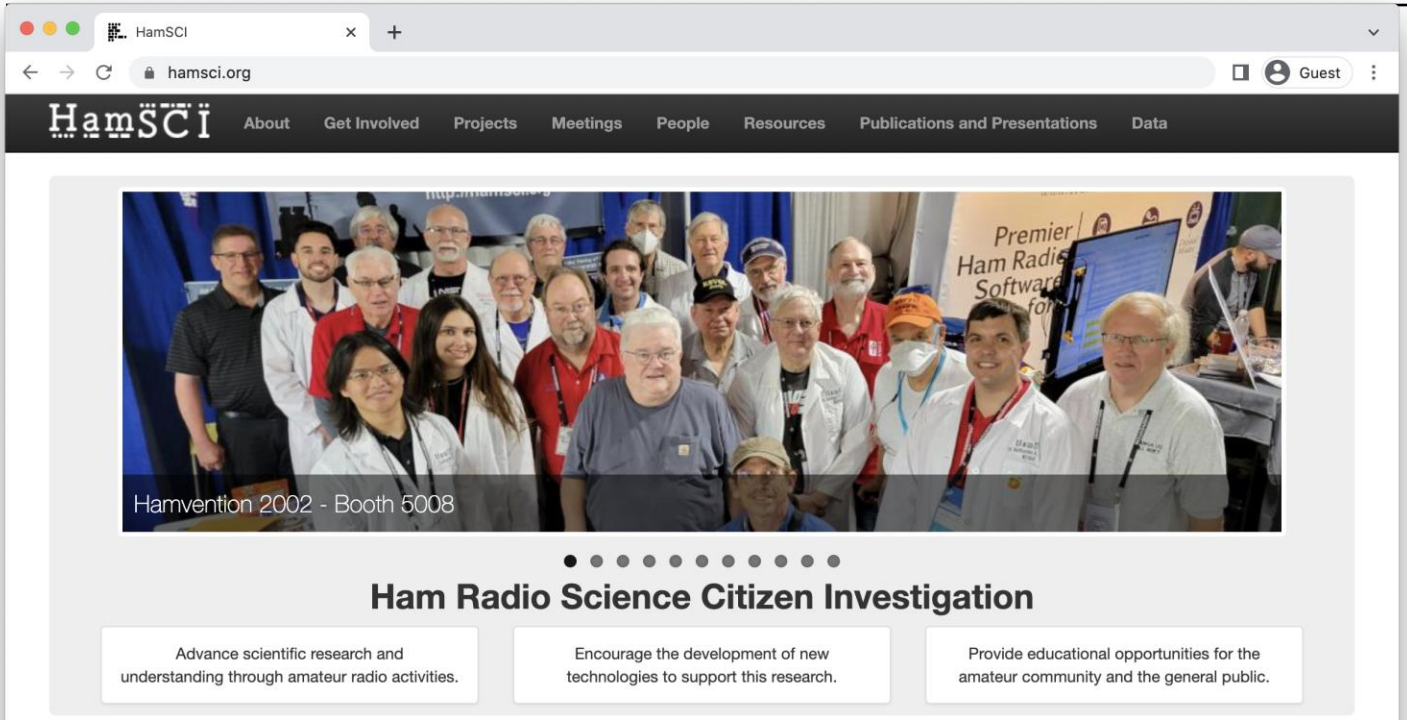
SuperDARN Radar, McMurdo Station Antarctica

Photo N. Frissell, 2014

nathaniel.frissell@scranton.edu


KL7/KJ4OAP
KL7/W2NAF
Adak Island
IOTA NA-039

HamSCI Ham radio Science Citizen Investigation



NSF

NASA Partner

ARDC
AMATEUR RADIO DIGITAL COMMUNICATIONS

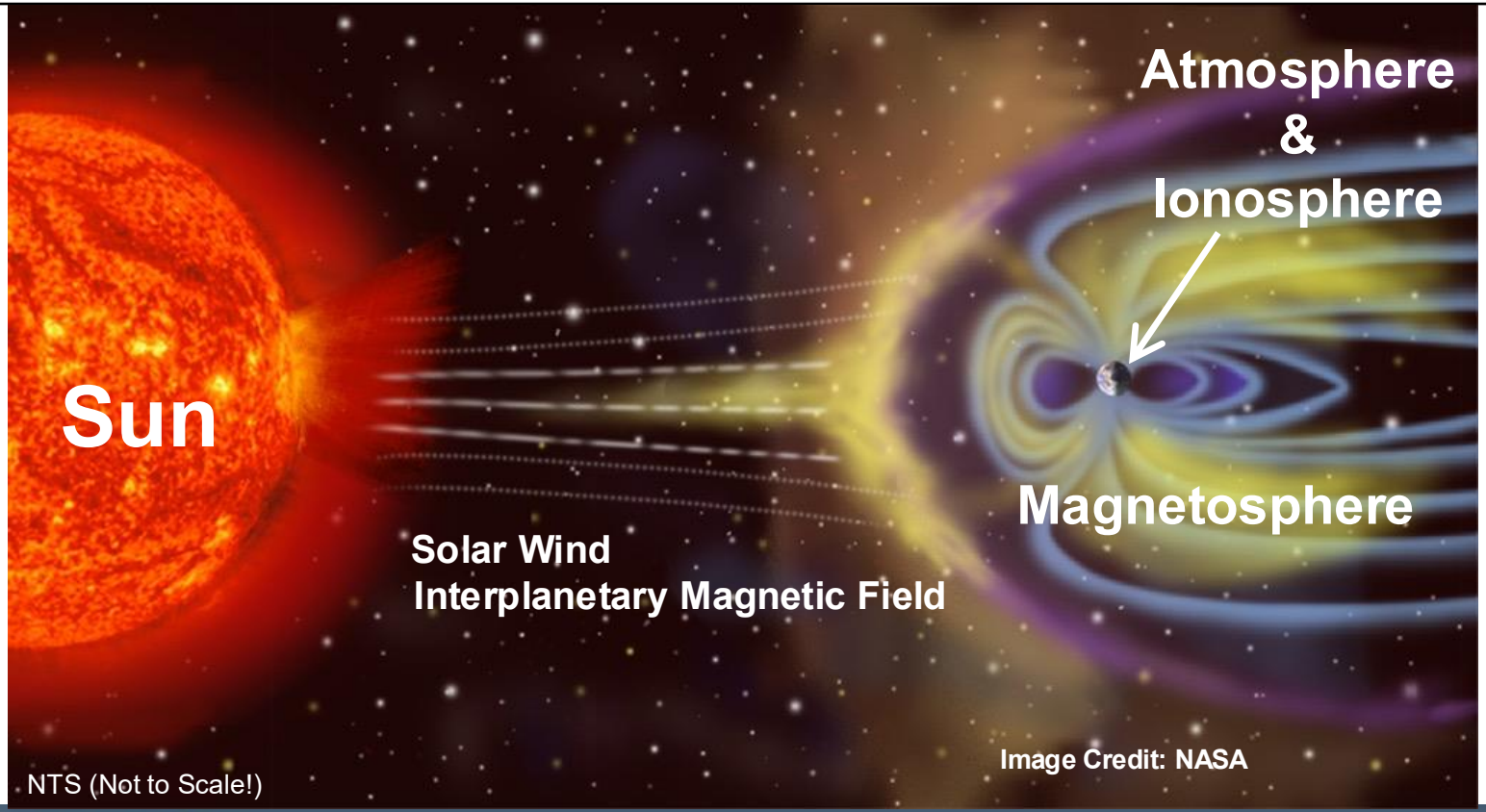
The YASME FOUNDATION

Frankford Radio Club
Proficiency Through Competition

- **Official NASA Citizen Science Project**
- **Generated over $6.2 million in federal and private foundation research funding since 2019 (including collaborative grants).**

nathaniel.frissell@scranton.edu

The Geospace System



The Ionosphere

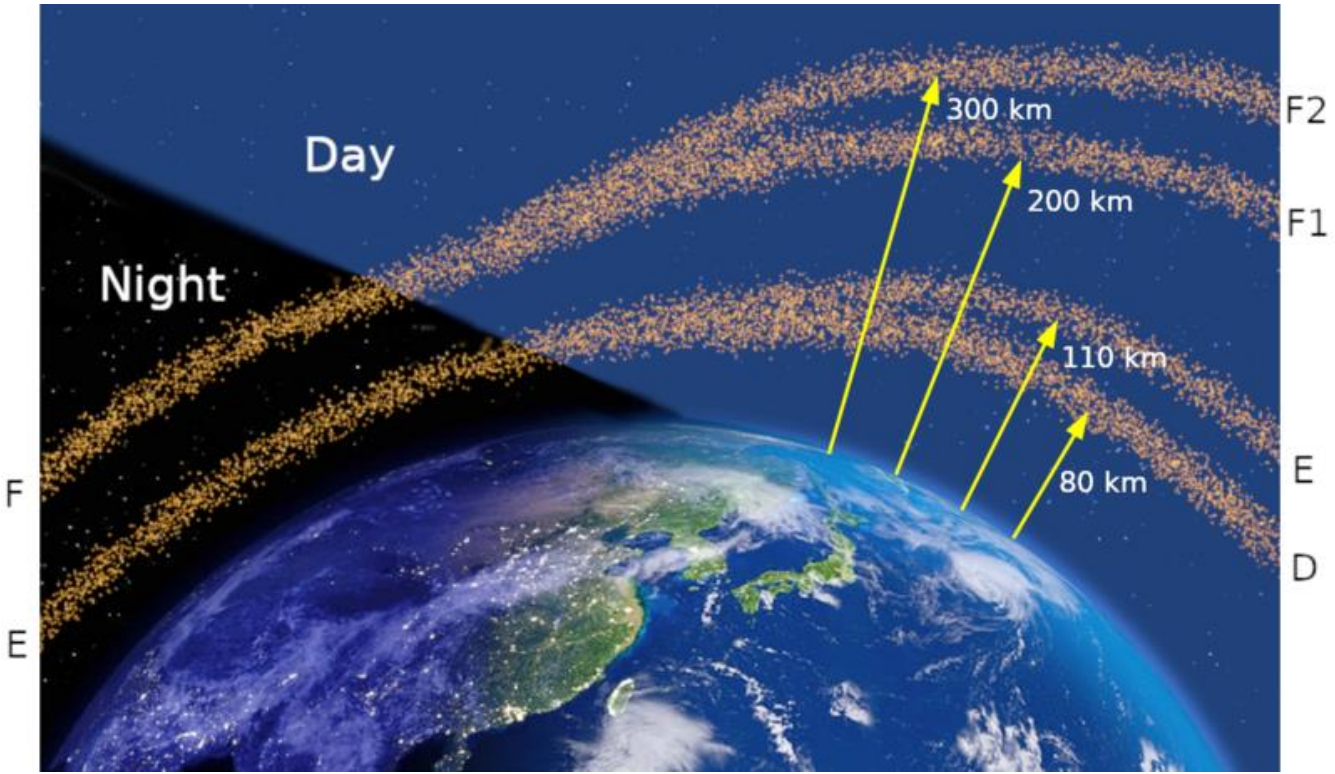
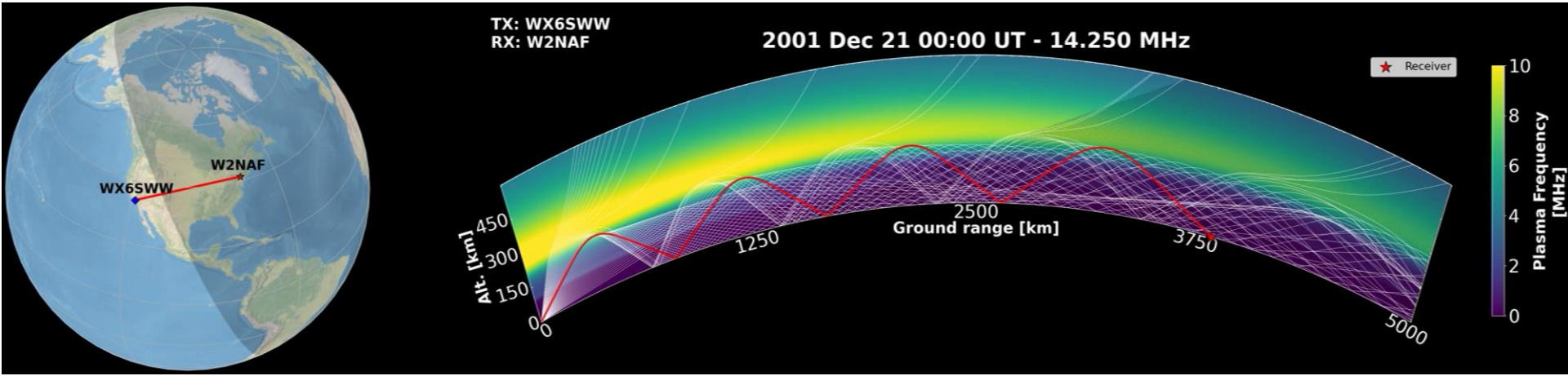


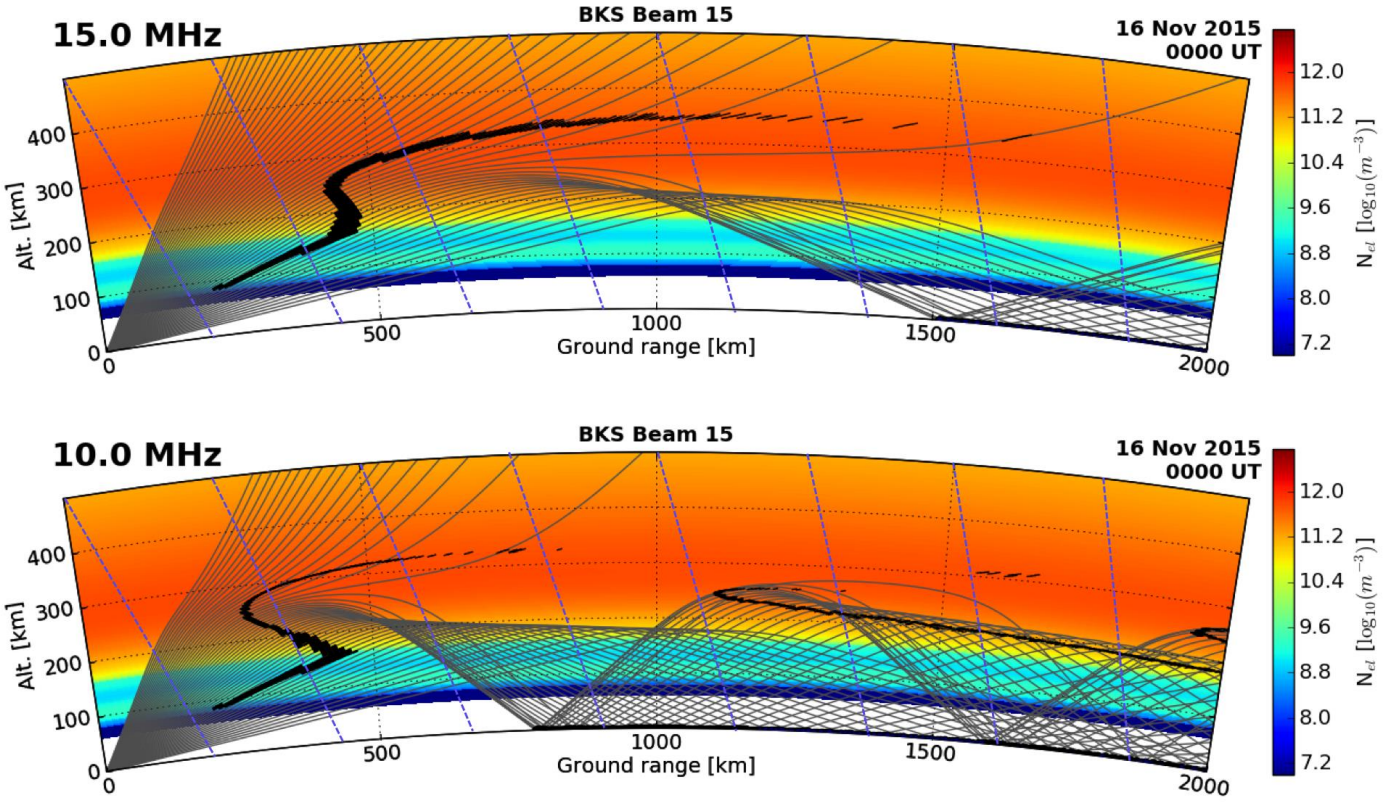
Figure by Carlos Molina (https://commons.wikimedia.org/wiki/File:Ionospheric_layers_from_night_to_day.png)

Ionospheric Skip Propagation



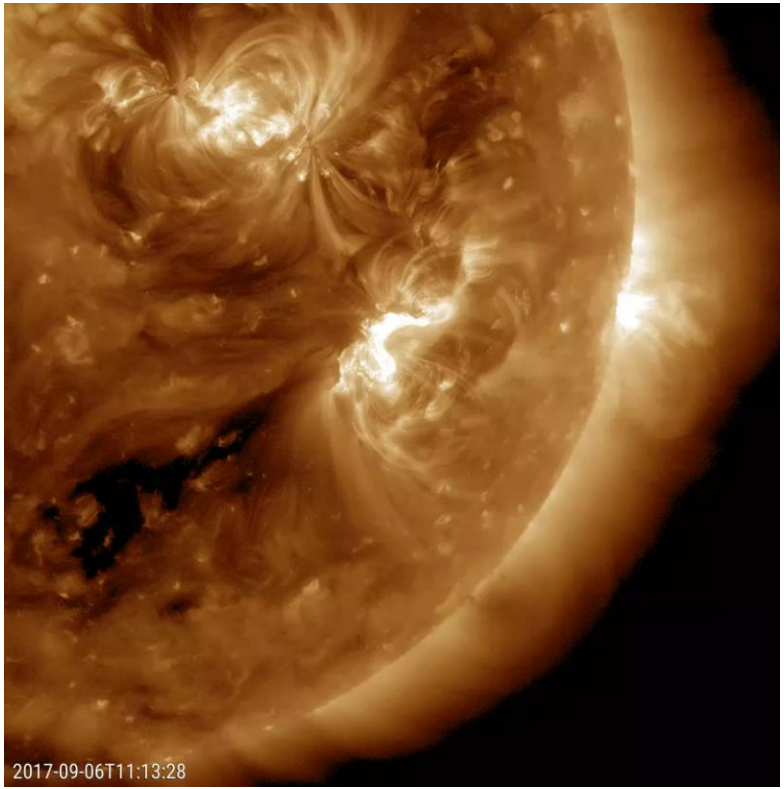
14 MHz (20 m)

Refraction as a Function of Frequency



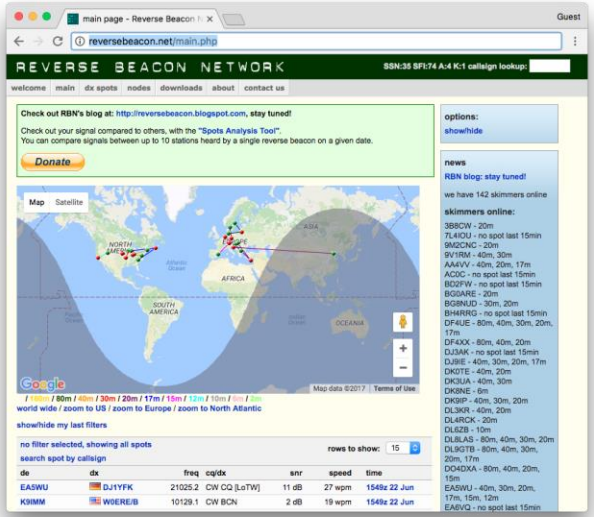
nathaniel.frissell@scranton.edu

Solar Flares

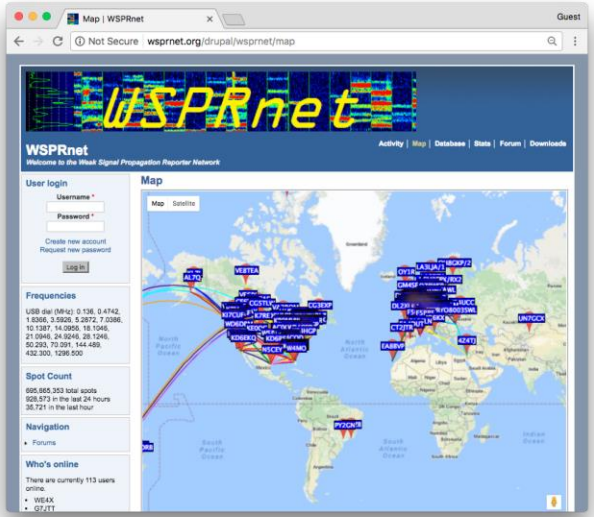


NASA SDO Observation of X9.3 Solar Flare on Sept 6, 2017

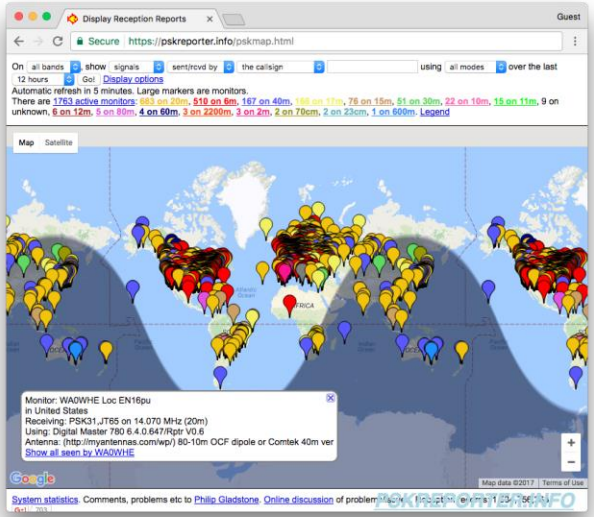
Amateur Radio Observation Networks



Reverse Beacon Network (RBN)
reversebeacon.net



WSPRNet
wsprnet.org



PSKReporter
pskreporter.info

- Quasi-Global
- Organic/Community Run
- Unique & Quasi-random geospatial sampling

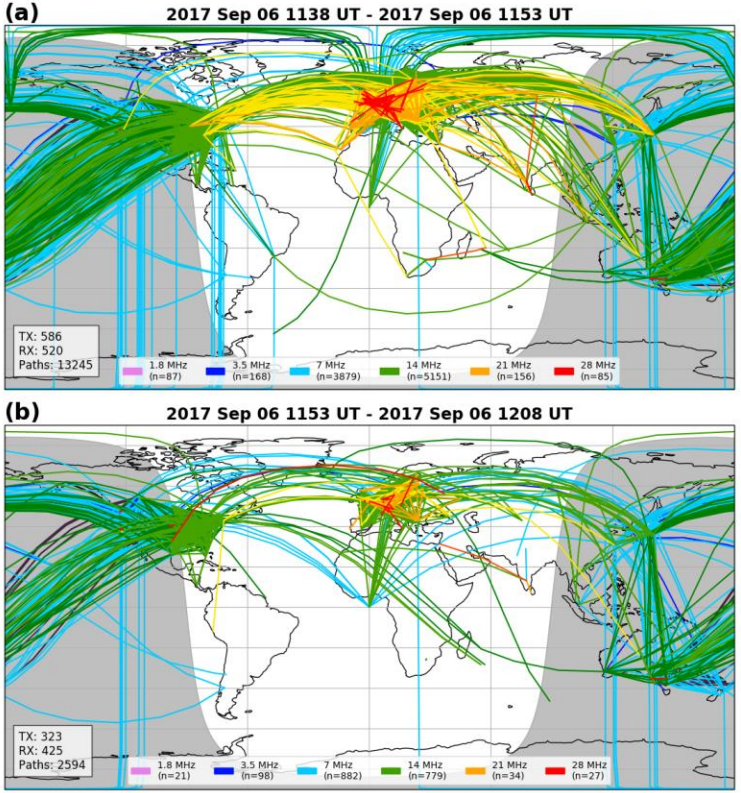
- Data back to 2008 (A whole solar cycle!)
- Available in real-time!

HF Response to Solar Flare

13,245 Paths

6 Sept 2017
1153 UT
X9.3 Flare

2,594 Paths

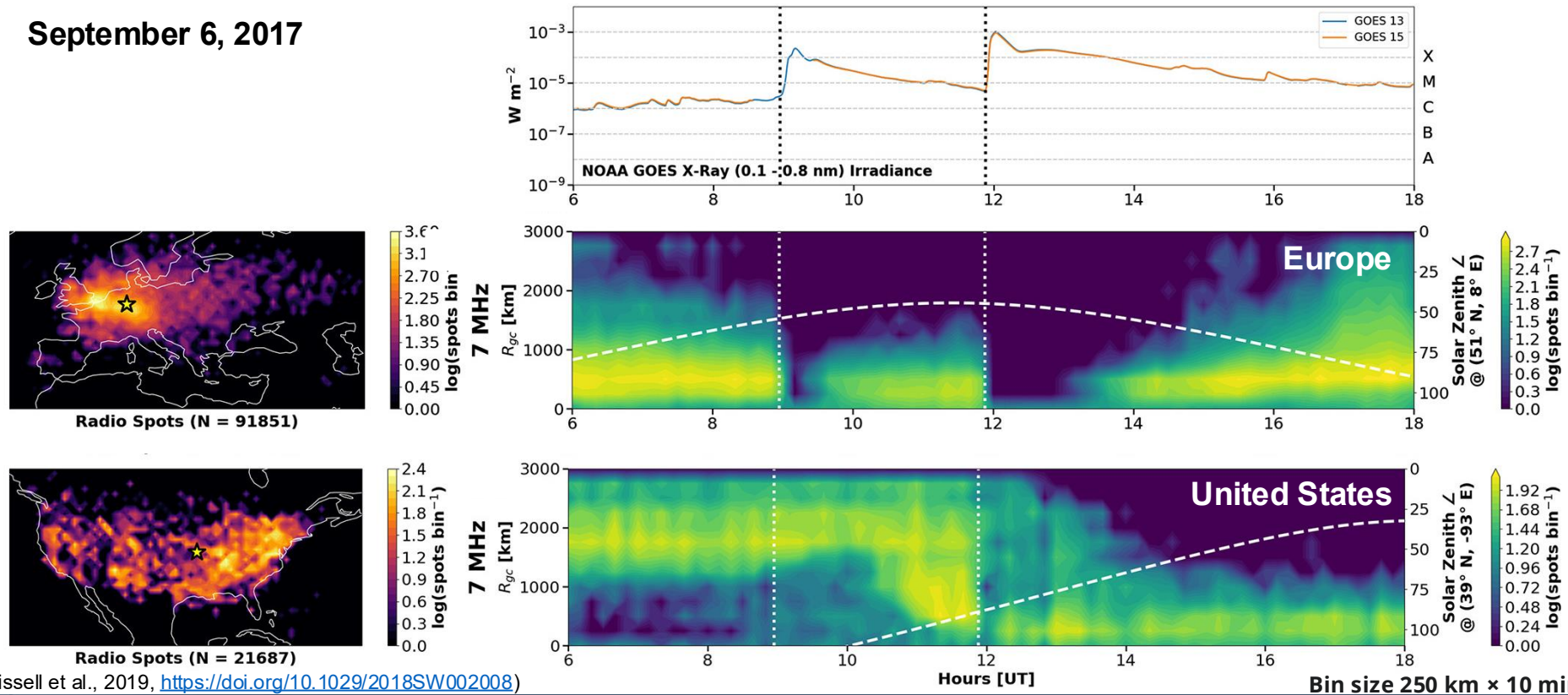


28 MHz
21 MHz
14 MHz
7 MHz
3.5 MHz
1.8 MHz

nathaniel.frissell@scranton.edu

Solar Flare Impacts on the Ionosphere

September 6, 2017



(Frissell et al., 2019, https://doi.org/10.1029/2018SW002008)

Bin size 250 km × 10 min

Solar Eclipses

Total

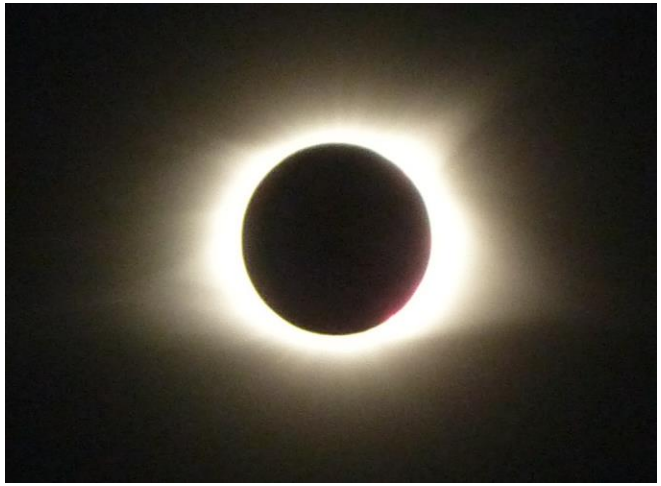


Photo by Jim Sackerman, KC2ZFK

Partial

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

Annular

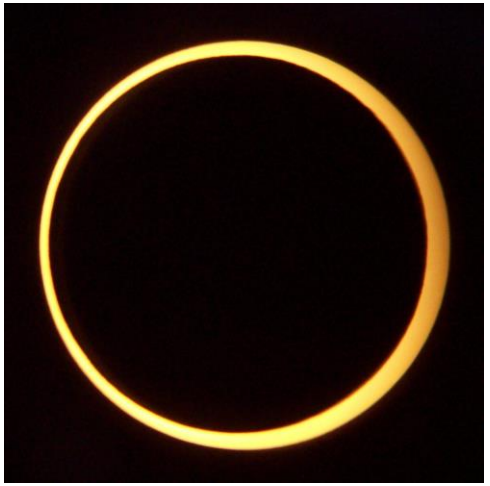
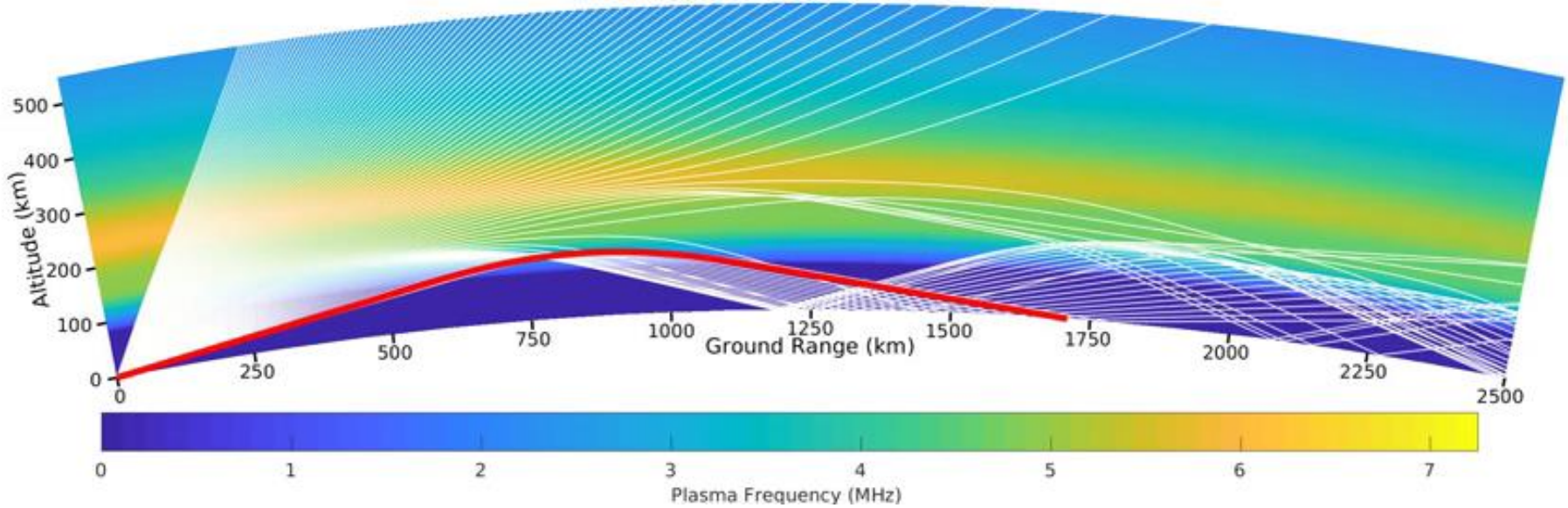


Photo By Smrgeog~commonswiki
(https://commons.wikimedia.org/wiki/File:Annular_Eclipse,_Taken_from_Middlegate,_Nevada_on_May_20,_2012.jpg)

Eclipse Ionospheric Radio Effects

14 MHz

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

nathaniel.frissell@scranton.edu

2017 North American Solar Eclipses

- **Total: August 21, 2017**
  - Partial Eclipse Begins 1604 UTC in Oregon
  - Partial Eclipse Ends 2013 UTC in South Carolina

Solar Eclipse QSO Party (SEQP)

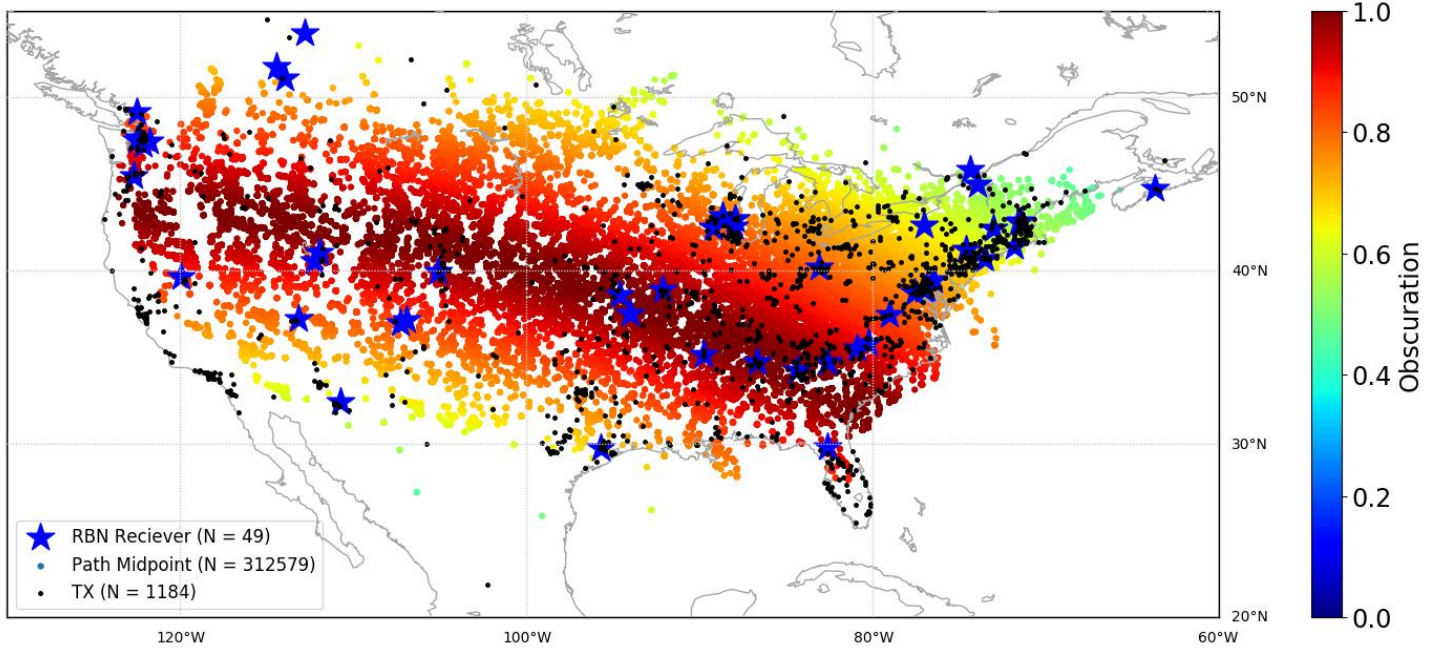
- **Contest-like**
  - 2 Points CW or Digital
  - 1 Point for Phone
  - Multiply Score by # of Grids
- **Exchange**
  - RST + 6 Character Grid Square
- **Data sources**
  - Reverse Beacon Network
  - PSKReporter
  - WSPRNet
  - Participant-submitted logs

http://hamsci.org/eclipse

Graphic by Spencer Gunning

nathaniel.frissell@scranton.edu

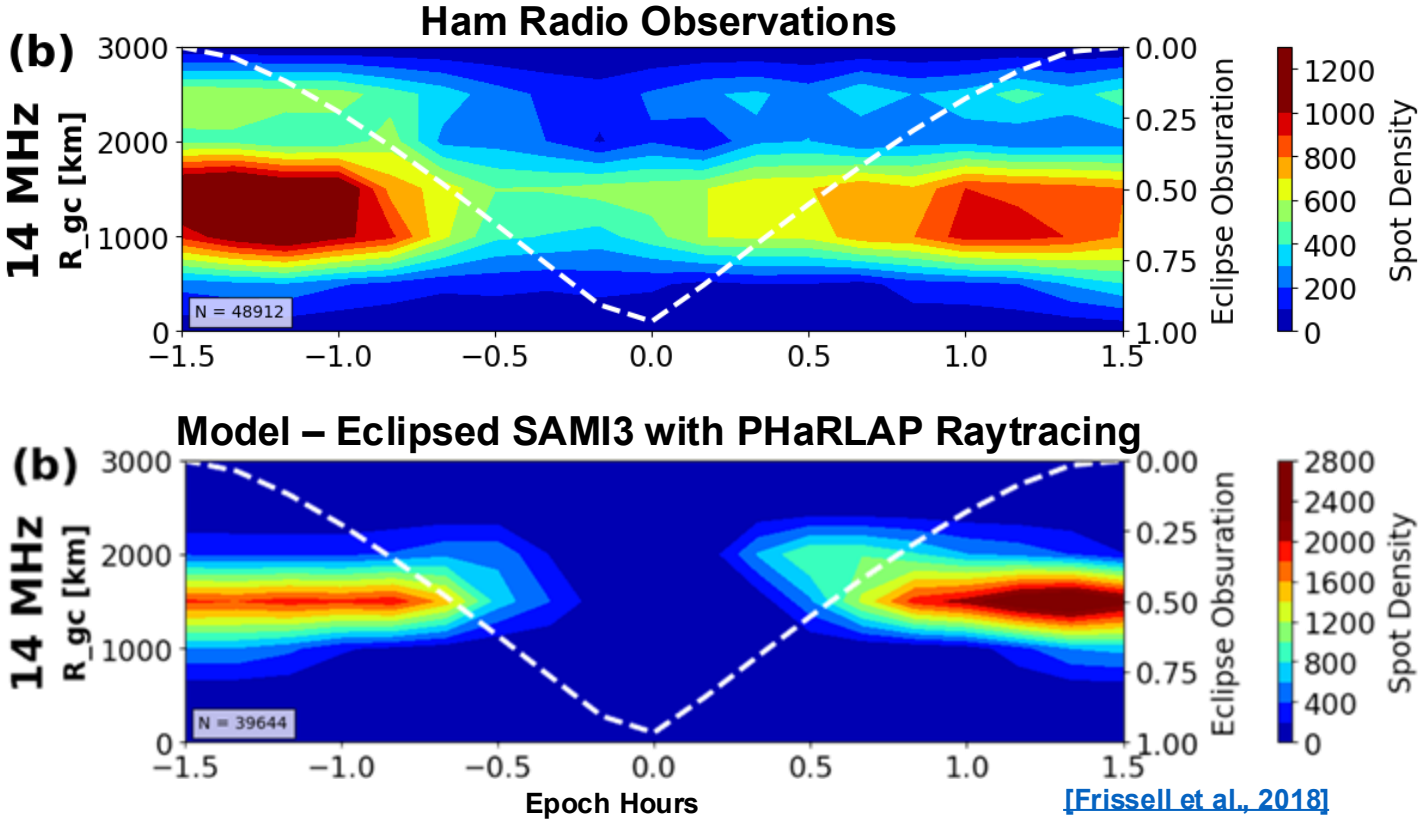
2017 Solar Eclipse QSO Party RBN Observations



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

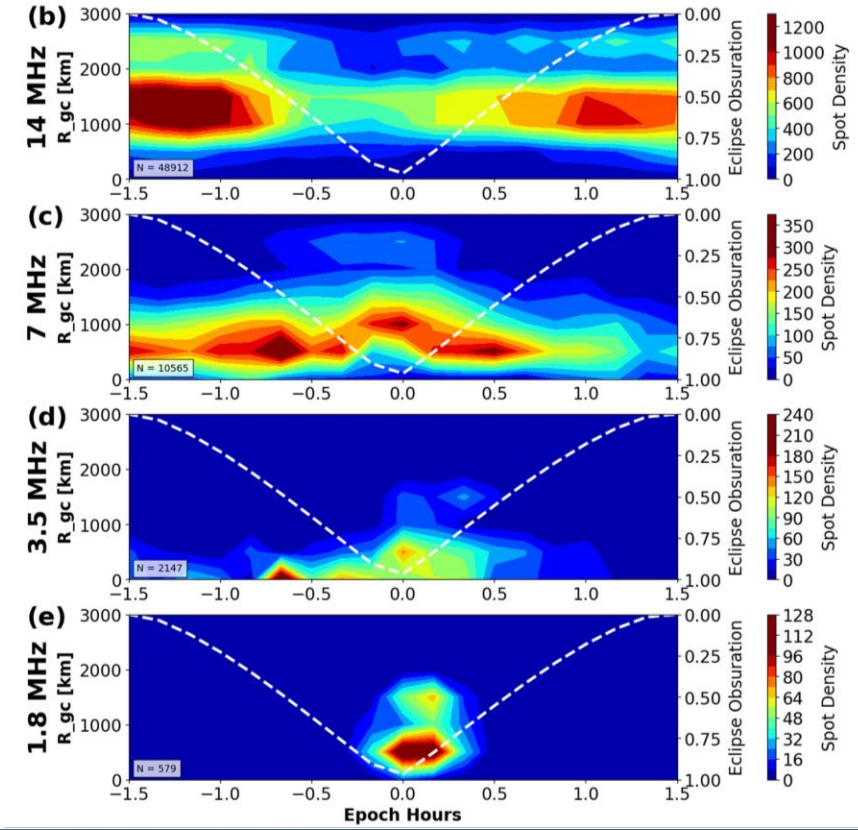
nathaniel.frissell@scranton.edu

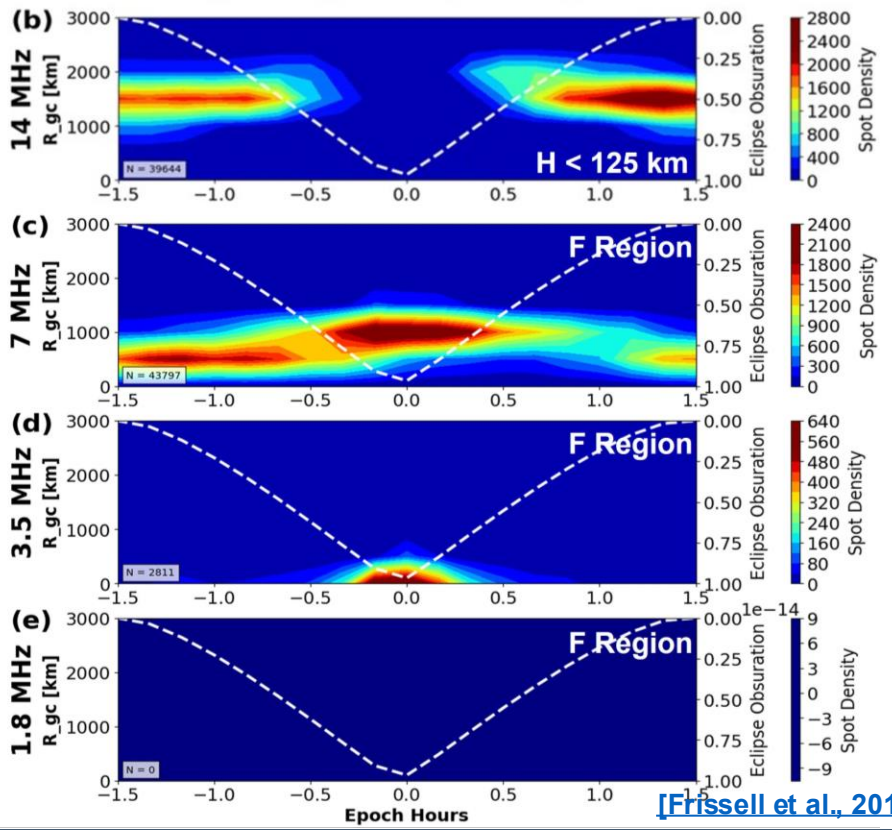
2017 SEQP Observations and Model Results



[Frissell et al., 2018]

2017 SEQP Observations and Model Results





[Frissell et al., 2018]

nathaniel.frissell@scranton.edu

2023/2024 North American Solar Eclipses

- **Annular: October 14, 2023**
  - Partial Eclipse Begins ~1500 UTC in Oregon
  - Partial Eclipse Ends ~1840 UTC in Texas

- **Total: April 8, 2024**
  - Partial Eclipse Begins ~1710 UTC in Texas
  - Partial Eclipse Ends ~2040 UTC in Maine

Festivals of Eclipse Ionospheric Science

Graphic by Vikki A. Lawhon,
University of Scranton

nathaniel.frissell@scranton.edu

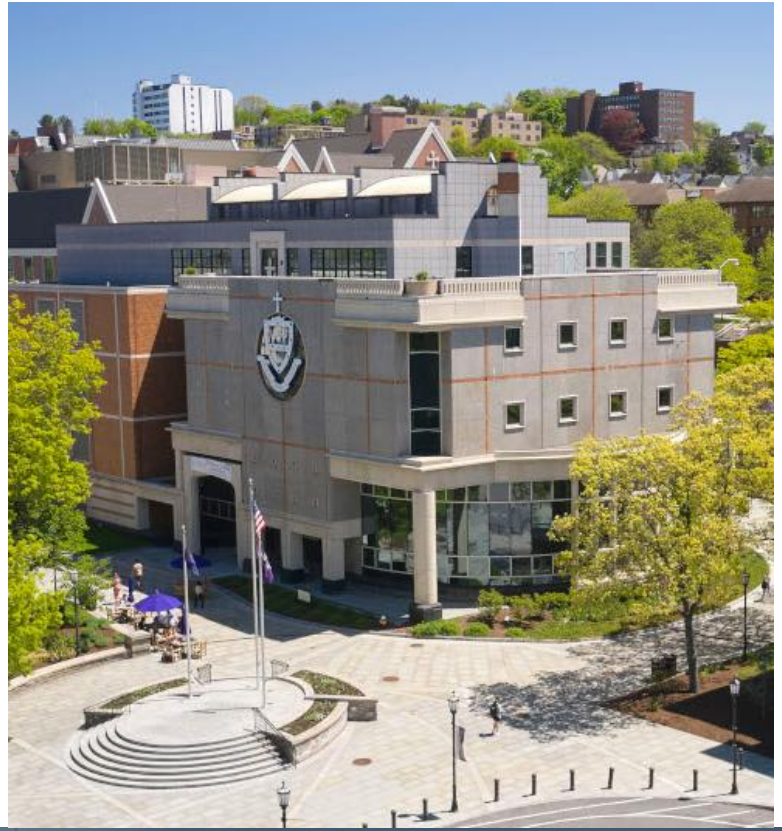
2023/2024 Festivals of Eclipse Ionospheric Science

1. Solar Eclipse QSO Party (SEQP)
   & Gladstone Signal Spotting Challenge
2. Personal Space WX Station HF Doppler Experiment
3. HF Time Difference of Arrival Experiment
4. Medium Wave AM Doppler Experiment
5. Very Low Frequency (VLF) Experiments

https://hamsci.org/eclipse

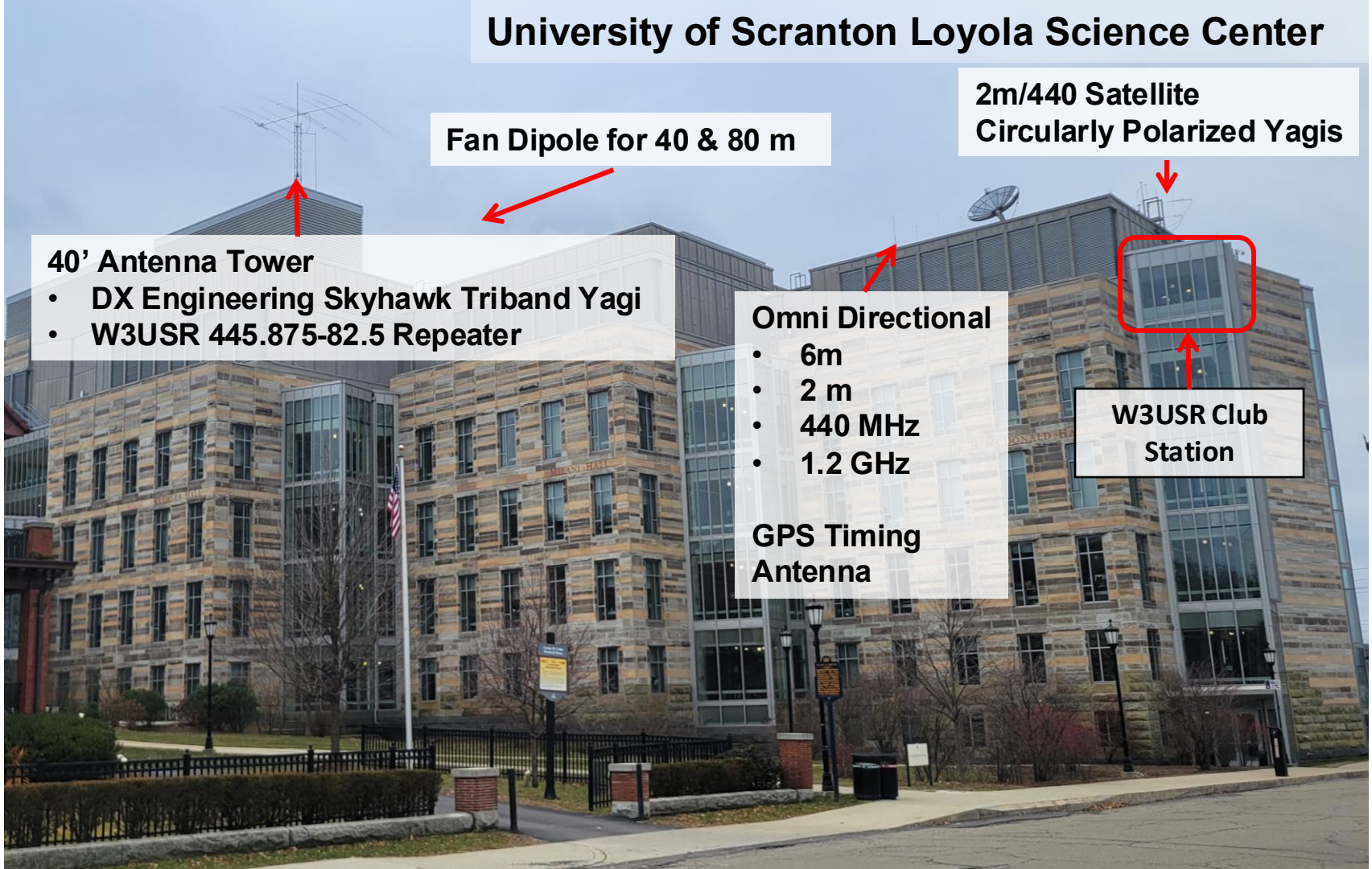
nathaniel.frissell@scranton.edu

The University of Scranton



- Jesuit Liberal Arts University
- ~5,000 Students
- Located in Downtown Scranton, PA
- Undergraduate degrees in Electrical, Computer, Mechanical Engineering, Physics, and more!

nathaniel.frissell@scranton.edu


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
Omni Directional
• 6m
• 2 m
• 440 MHz
• 1.2 GHz
GPS Timing
Antenna
W3USR Club
Station

8 April 2024 SEQP @ W3USR

Used with permission from WNEP

nathaniel.frissell@scranton.edu

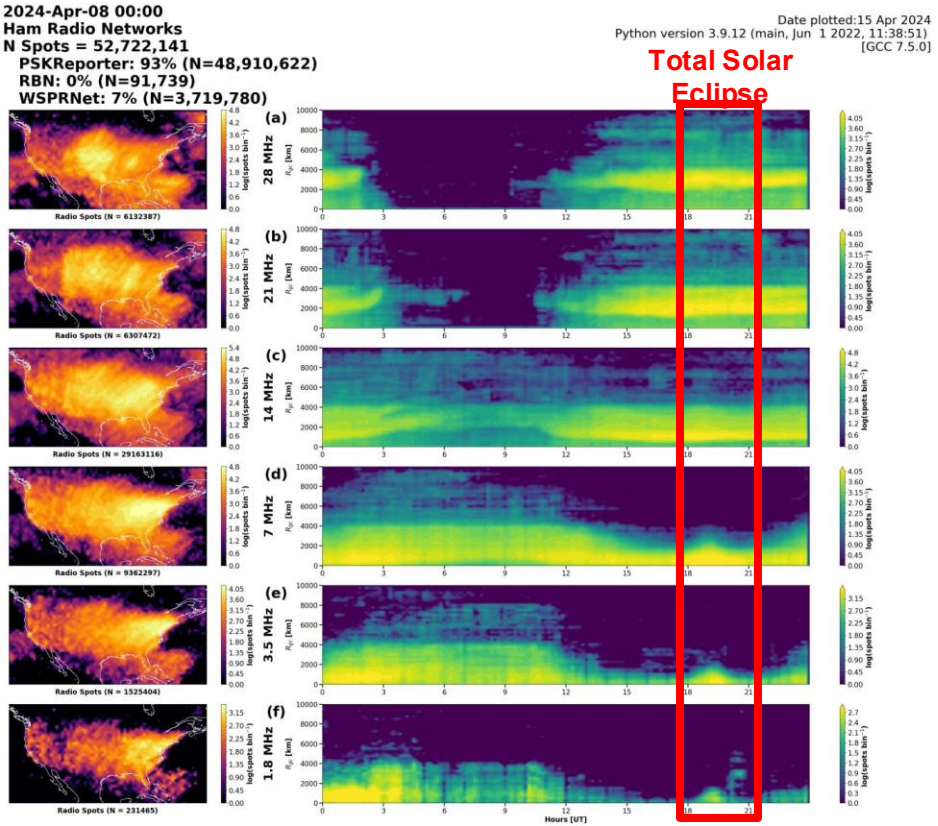
Solar Eclipse QSO Party

https://hamsci.org/seqp

nathaniel.frissell@scranton.edu

Solar Eclipse QSO Party

- **Radio contest where hams communicate before, during, and after solar eclipse.**
- **Data sources**
  - Reverse Beacon Network
  - PSKReporter
  - WSPRNet
  - Participant-submitted logs



nathaniel.frissell@scranton.edu

Spot Density: Continually Operated Tx-Rx

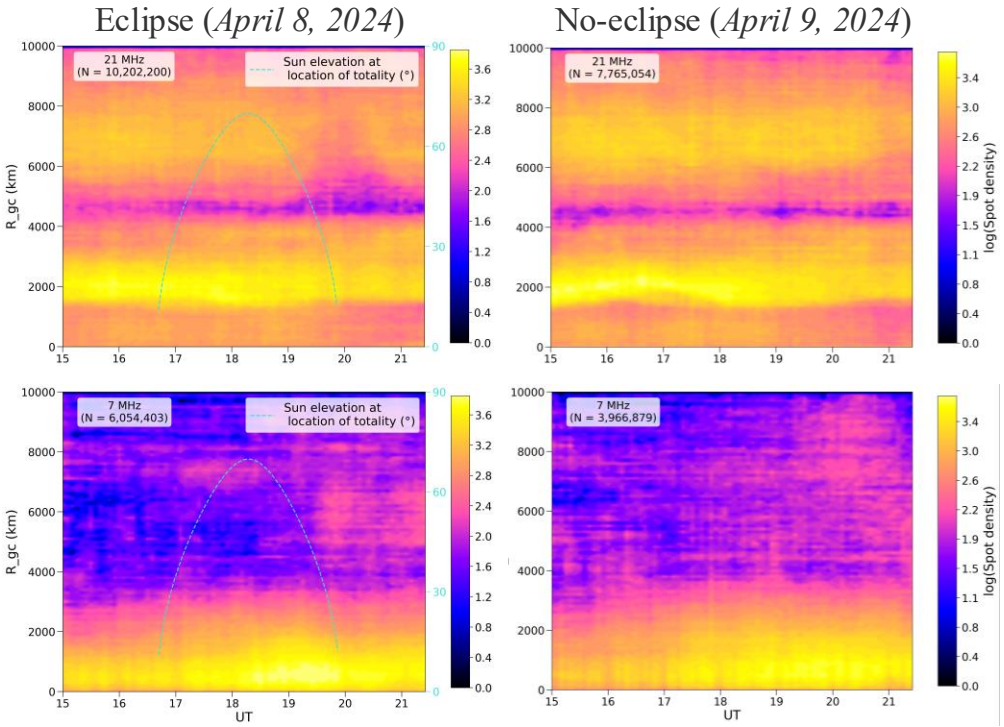


Fig: spots density with continually operated Tx and Rx stations only

Changes at longer ranges (~6000 km)

- **appeared after 19:30 UT**
- not during the entire eclipse interval!

Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology

Combined Effect of Eclipse & Sunset?

- Changes at longer ranges (~6000 km) appeared after 19:30 UT, not during the entire eclipse interval!
- Is it due to extended shadow like conditions (eclipse + sunset)?

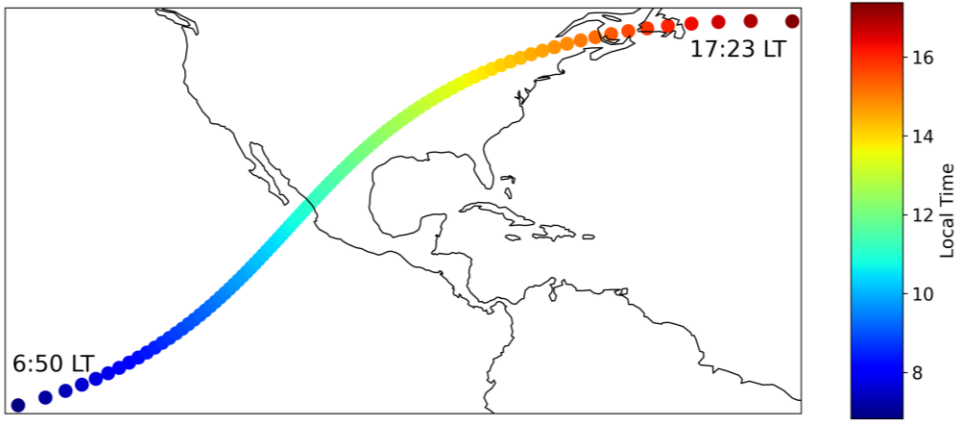


Fig: eclipse track with local time

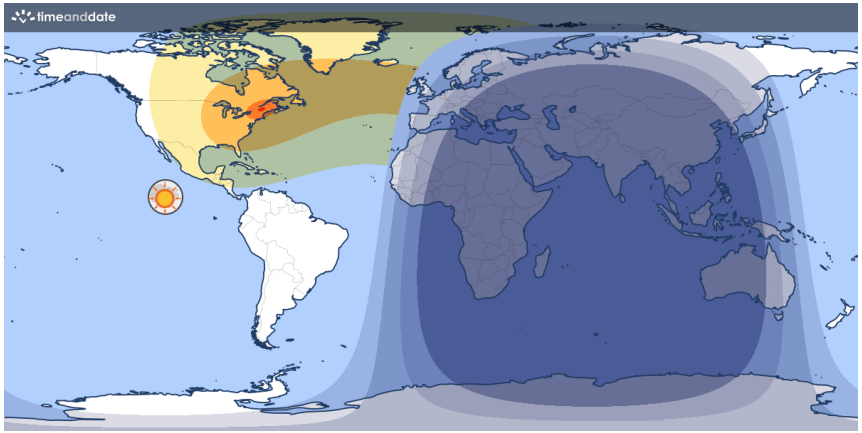


Fig: eclipse shadow at 19:30 UT + day-night conditions

https://www.timeanddate.com

Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology

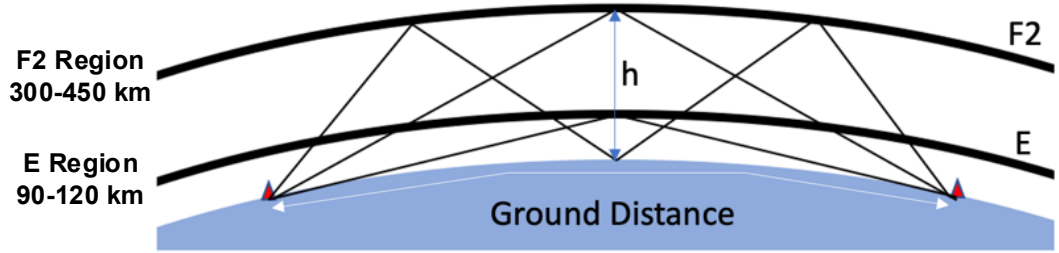
High Frequency **Time Difference of Arrival**

Steve Cerwin WA5FRF[1], Alexandros Papadopoulos KC3WUD[1,2], Gerard Piccini KD2ZHK[1,2], Nathaniel Frissell W2NAF[1,2], Tom McMahan K1FR[1], Paul Bilberry N5DUP[1], Samuel Blackshear AB5YO[1], Aidan Montare KB3UMD[1], and Kristina V. Collins KD8OXT[1,3]

[1]HamSCI Community
[2]University of Scranton
[3]Space Science Institute

Multipath TDOA to Deduce Layer Height

Objective: Measure changes in ionospheric layer height using unmodified, undisciplined amateur radios.



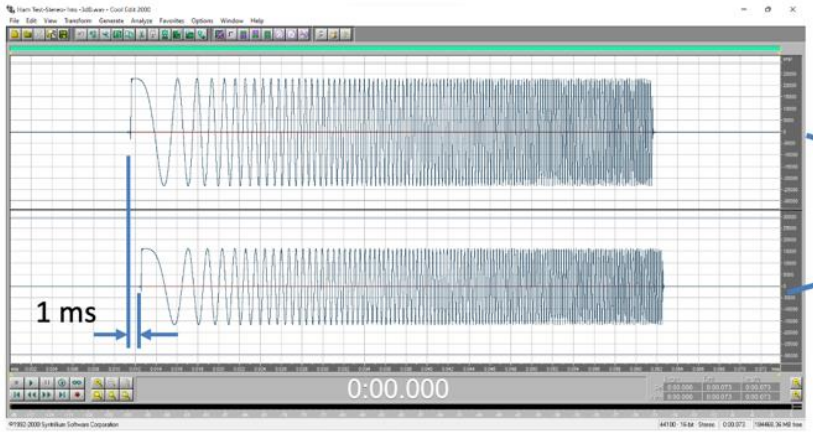


Fig 2a. Two 100 Hz/ms Chirps with 1 ms Time Delay. Delayed Chirp is 3 dB lower in Amplitude.

SUM

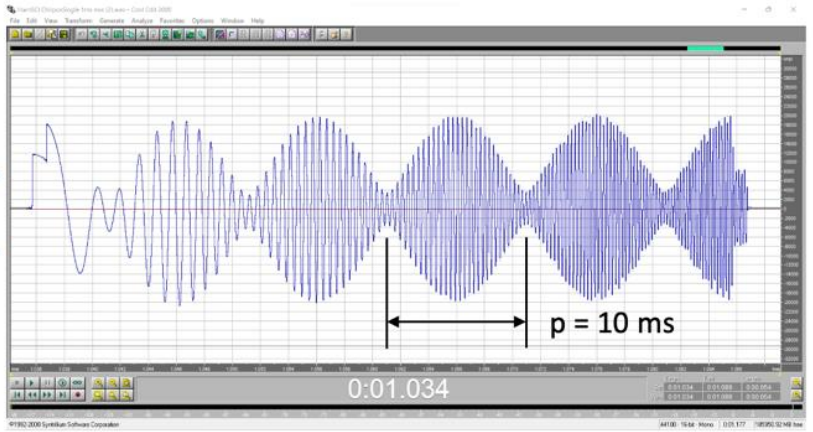
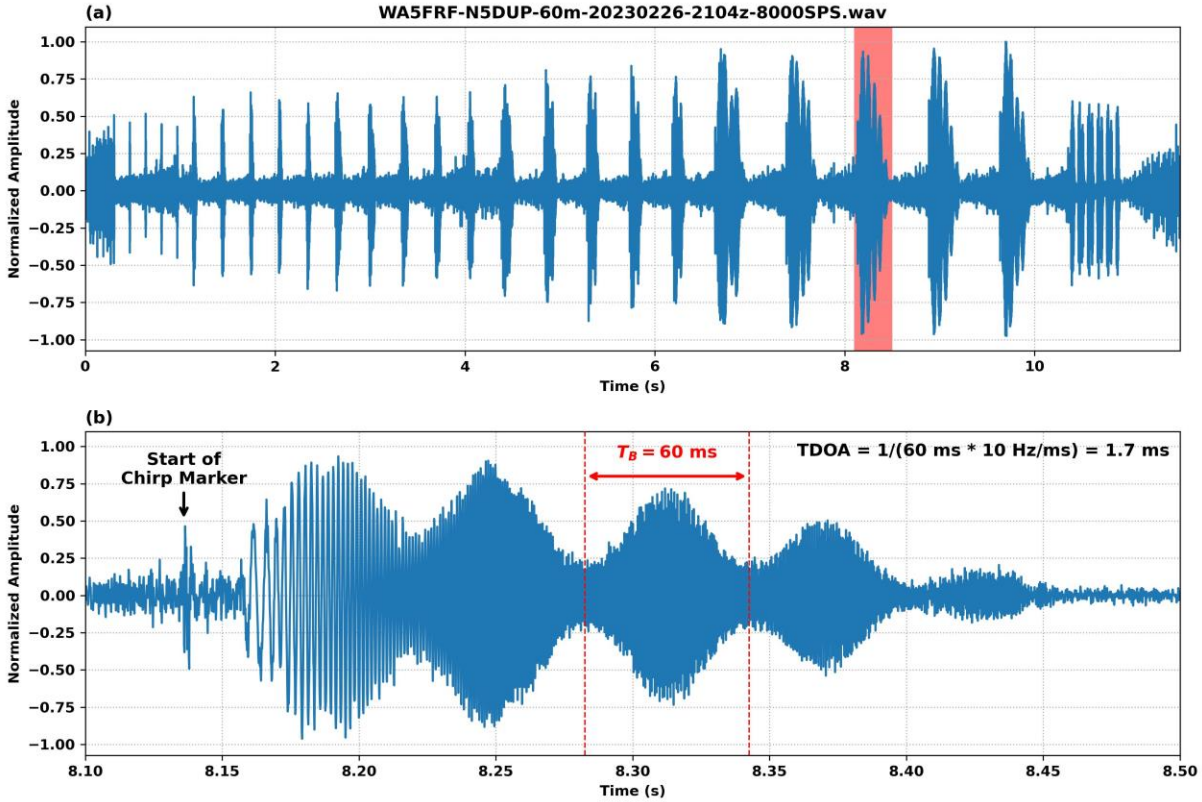


Fig 2b. Summation produces a Waveform with a Beat Note of Period p = 10 ms.

WA5FRF-N5DUP 26 Feb 2023 60 m



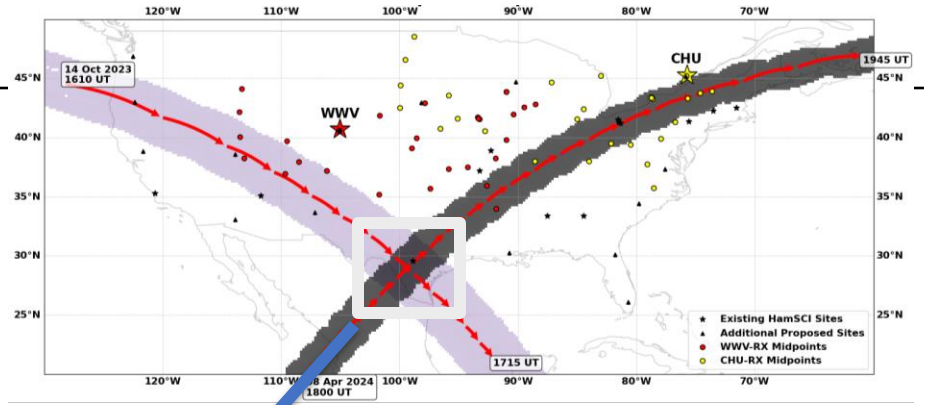
(a) TDOA waveform received over a 317 km path at 5.3 MHz near Austin, TX at 2104 UTC on 26 February 2023. Red box corresponds to expanded data shown in (b).

(b) Expanded view of a 10 Hz/ms chirp shows a beat note period of 60 ms, which corresponds to a 1.7 ms TDOA. Using the formulation for 1 and 2 hop multipath from the F2 region, the virtual height model calculates a reflection height of 277 km. This agrees well with the 280 km hmF2 data from the nearby Austin ionosonde.

nathaniel.frissell@scranton.edu

Eclipse TDOA Paths

- **Eclipses**
  - 14 October 2023 Annular Solar Eclipse
  - 8 April 2024 Total Solar Eclipse
- **Paths (All in Central Texas)**
  - WA5FRF-N5DUP (317 km ground distance)
  - WA5FRF-AB5YO (9 km ground distance)



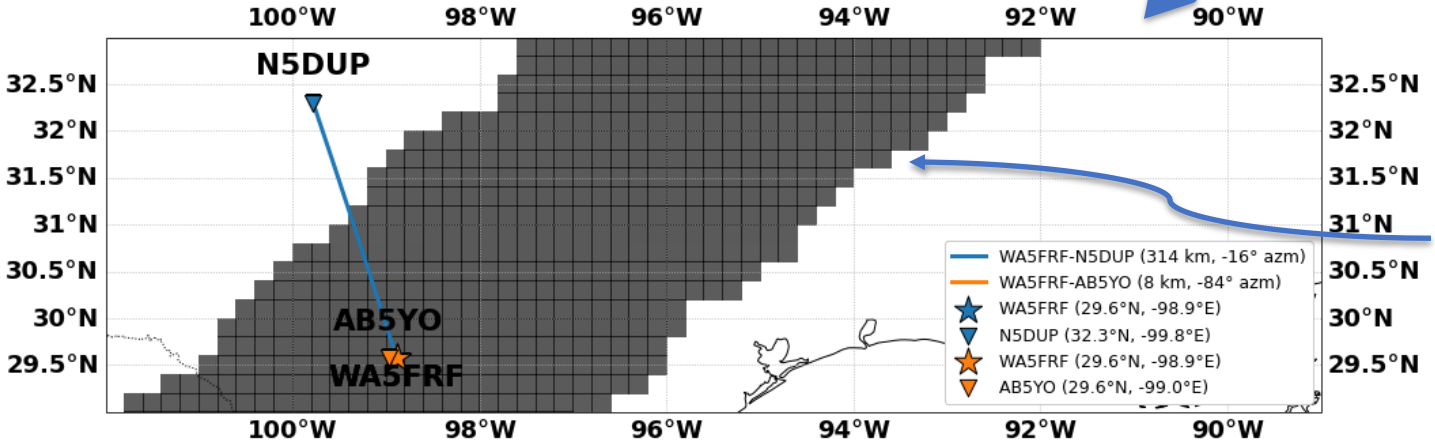
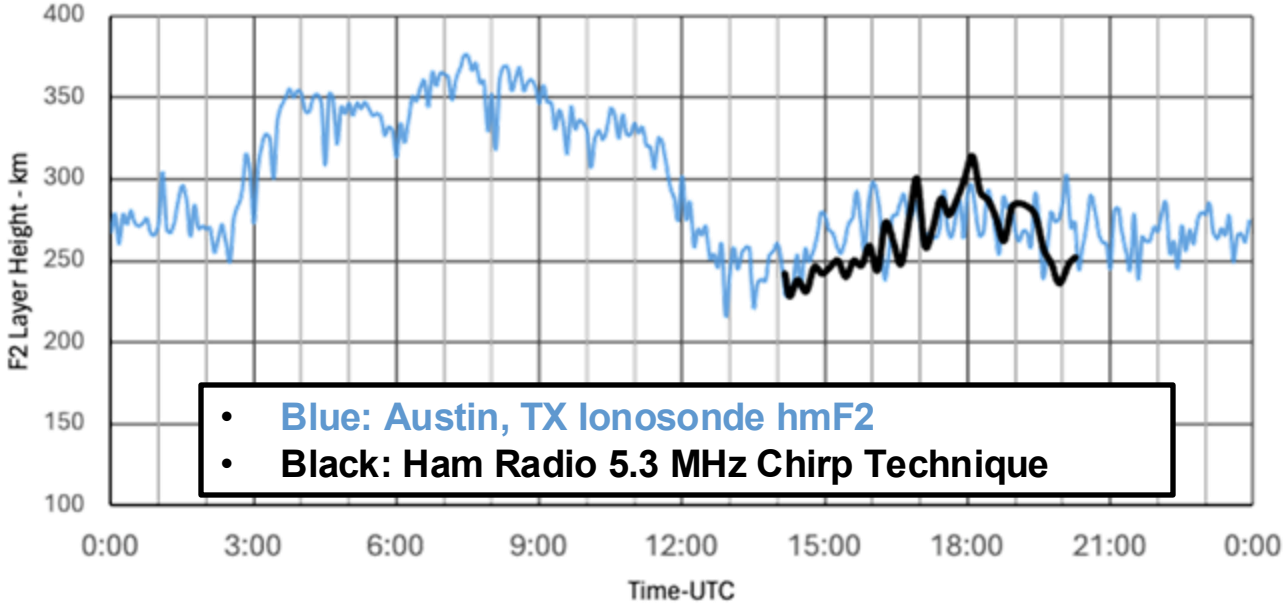


Fig 3. Graph illustrating the 8 April 2024 eclipse path and the distance between the TX station WA5FRF and the two RX stations N5DUP, AB5YO on different ground distances

HF TDOA Results – 8 April 2024

F2 Layer Height Calculated from WA5FRF-AB5YO 5.3 MHz TDOA Experiment
Overlaid on Austin Ionosonde hmF2 Data
Manual TDOA Scaling by WA5FRF
April 8, 2024 Total Eclipse



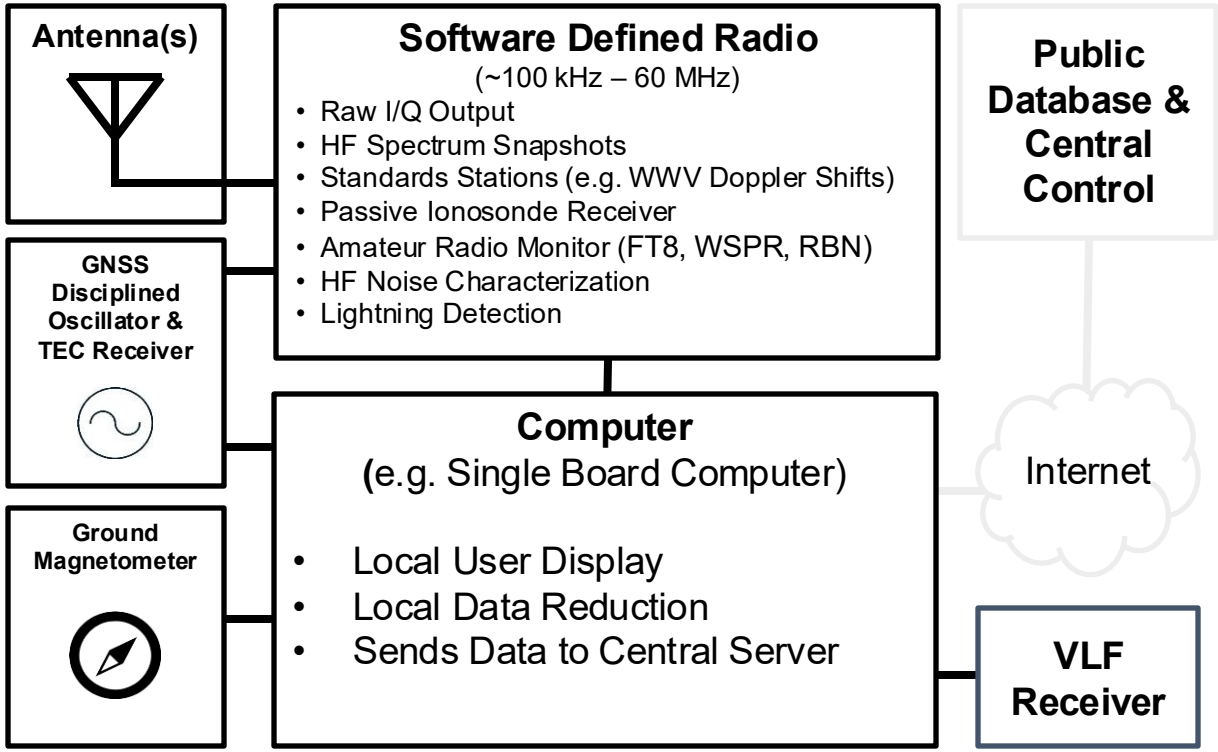
- Path: 8.8 km ground distance for Near Vertical Incidence Skywave
- Analysis by Steve Cerwin WA5FRF

HamSCI
Personal Space Weather Station

https://hamsci.org/psws

nathaniel.frissell@scranton.edu

HamSCI Personal Space Weather Station



For more information, visit http://hamsci.org/psws

HF Doppler Shift

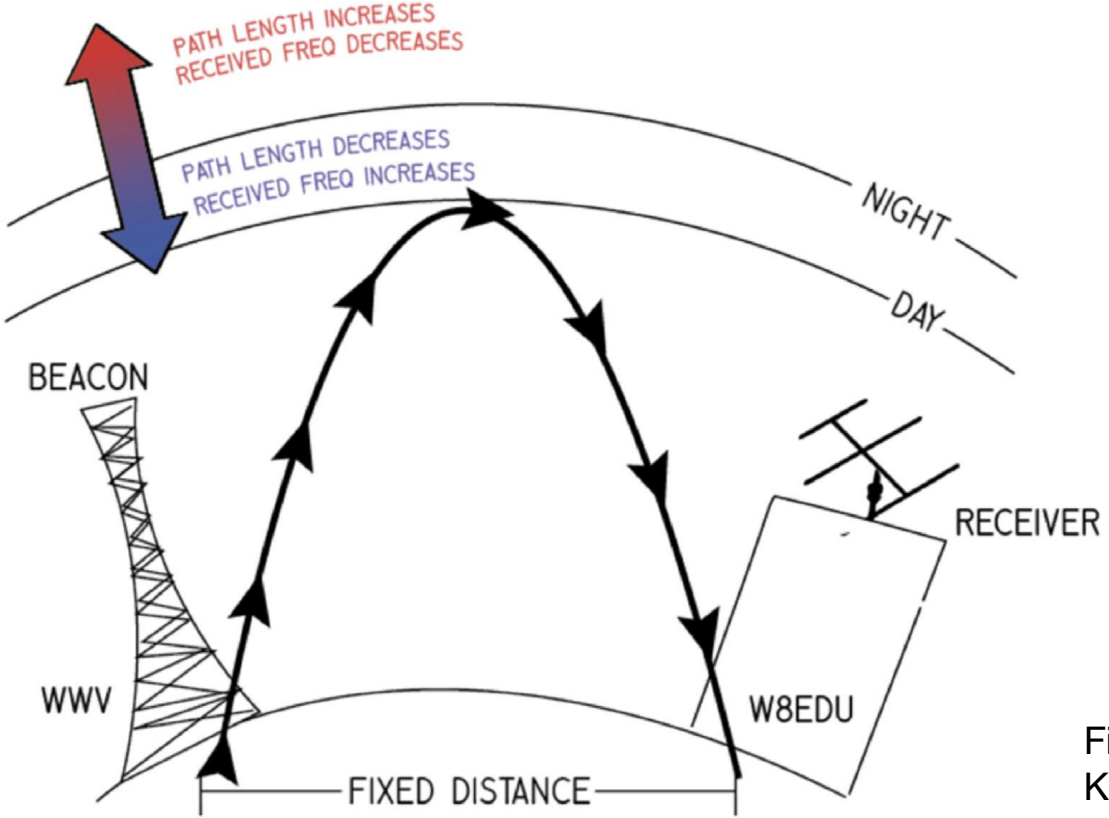


Figure by
Kristina Collins KD8OXT

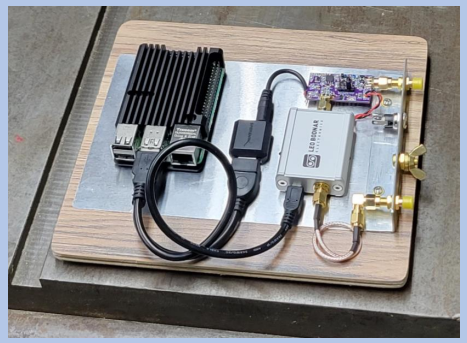
Collins et al. (2023)
https://doi.org/10.5194/essd-15-1403-2023

nathaniel.frissell@scranton.edu

Personal Space WX Station HF Receivers

Grape v1
- Single Frequency
- Build it yourself!

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



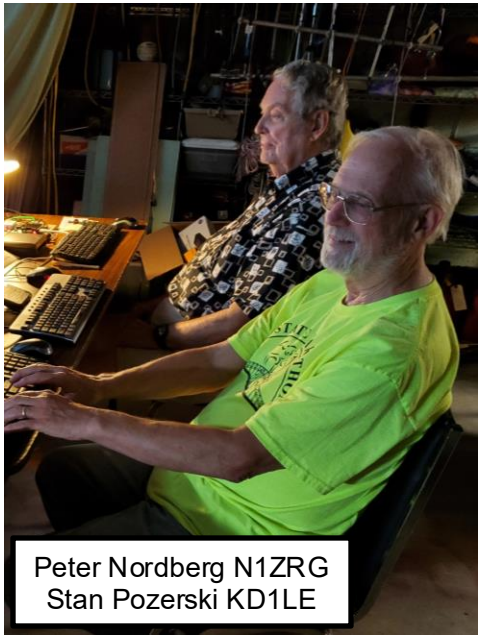
Development led by John Gibbons N8OBJ & Case Western Team

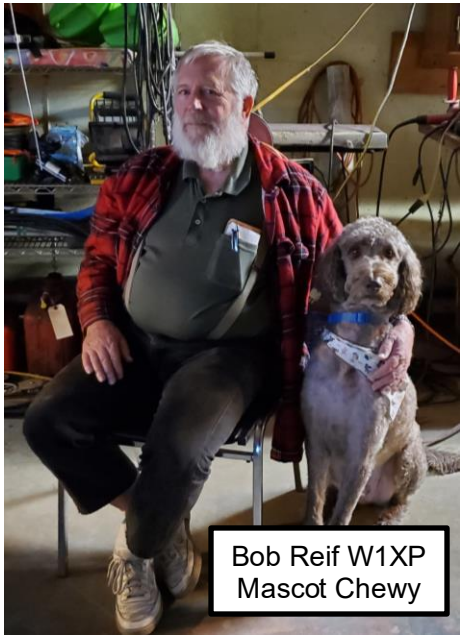
WSPRDaemon-Grape
- Uses RX-888 HF SDR, KA9Q-Radio & WSPRDaemon Software
- 9 (or more!) simultaneous HF Doppler bands
- Decodes WSPR/FSTRW spots, too!

Development led by Rob Robinett AI6VN, Phil Karn KA9Q, & TAPR

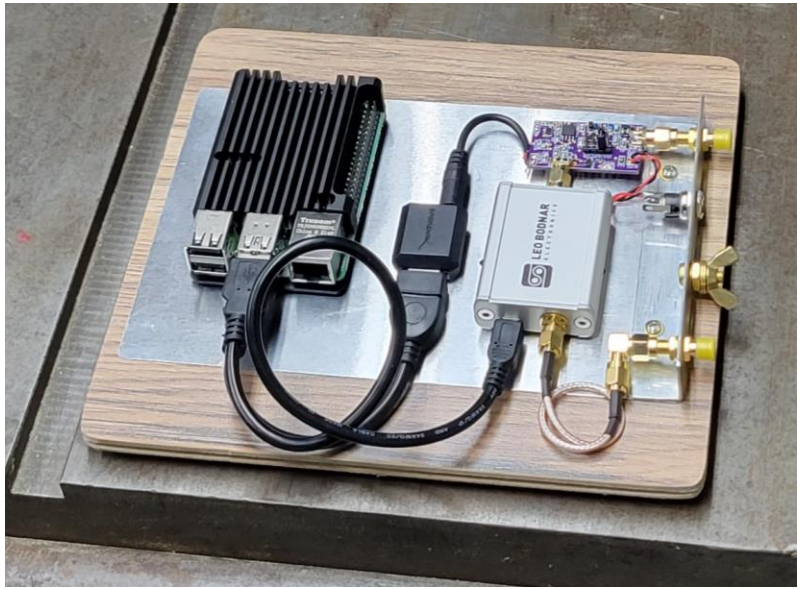
Grape Build & Distribution

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





Grape Build & Distribution

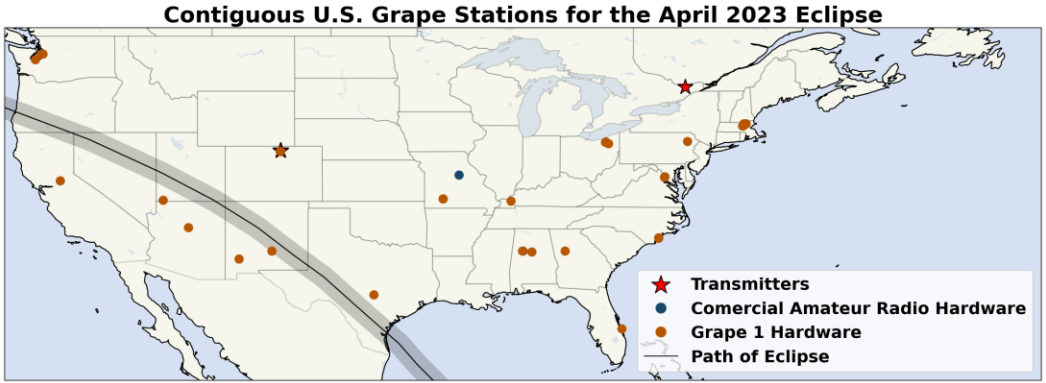


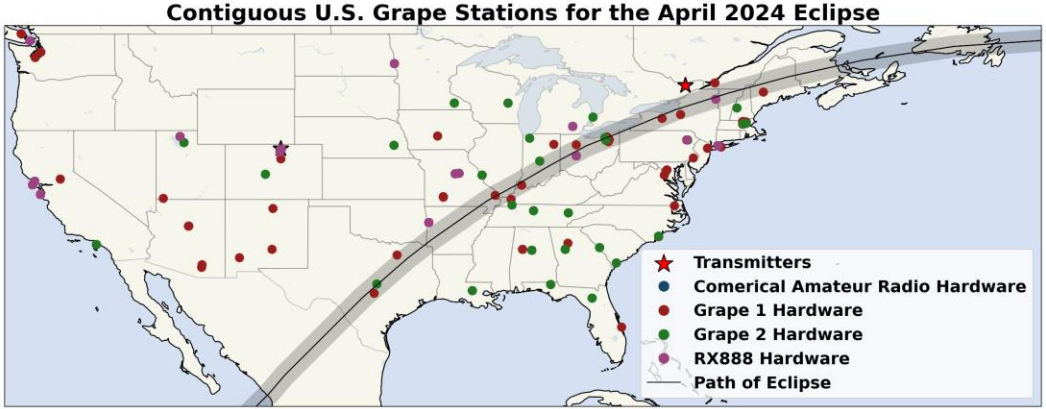
Thank you to entire Grape Team!

https://hamsci.org/grape1-contributors

nathaniel.frissell@scranton.edu

PSWS Grape Stations – 2023/2024 Eclipse





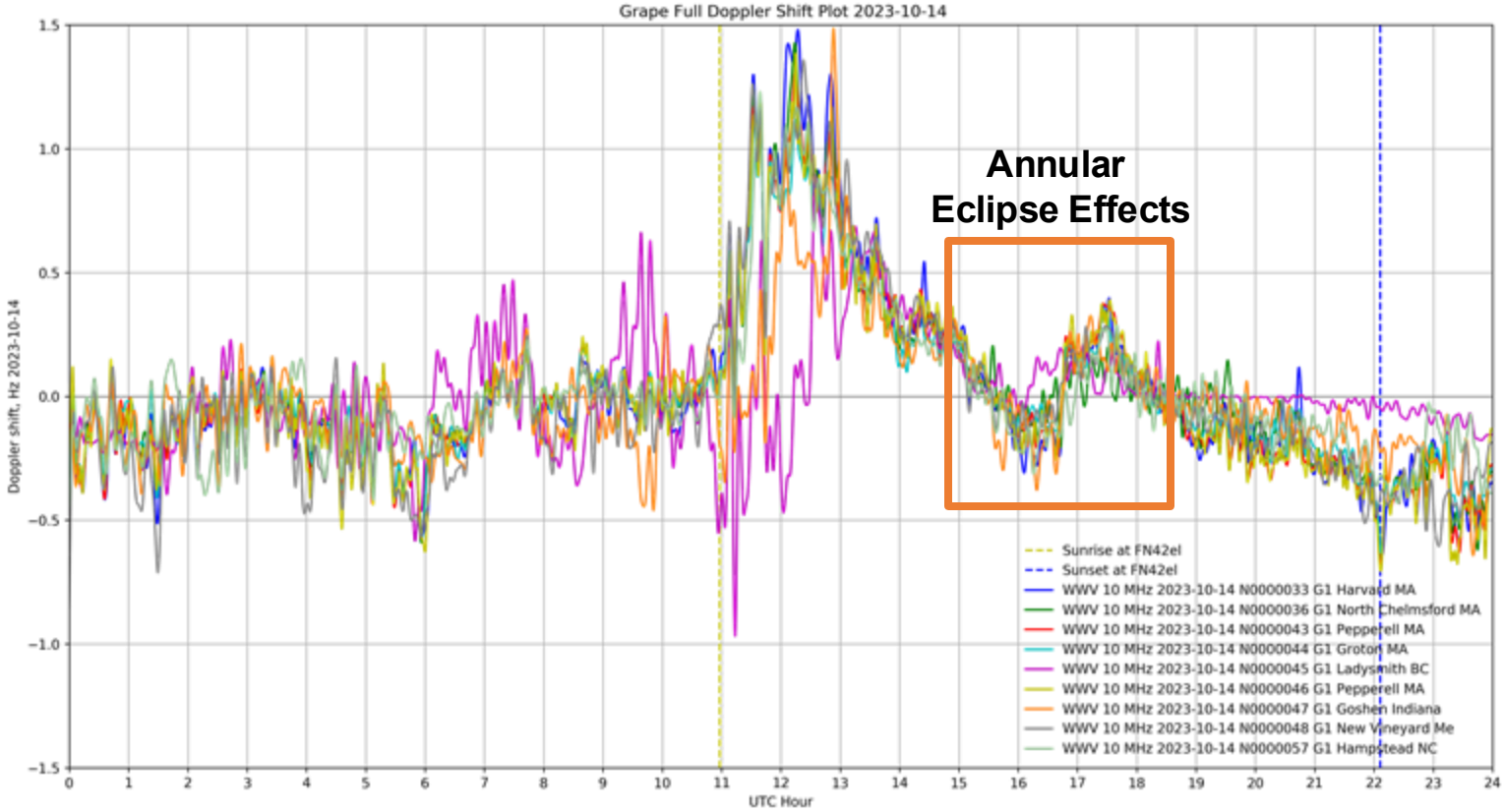
- Data available psws.hamsci.org

- Maps by Rachel Boedicker AC8XY

nathaniel.frissell@scranton.edu

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

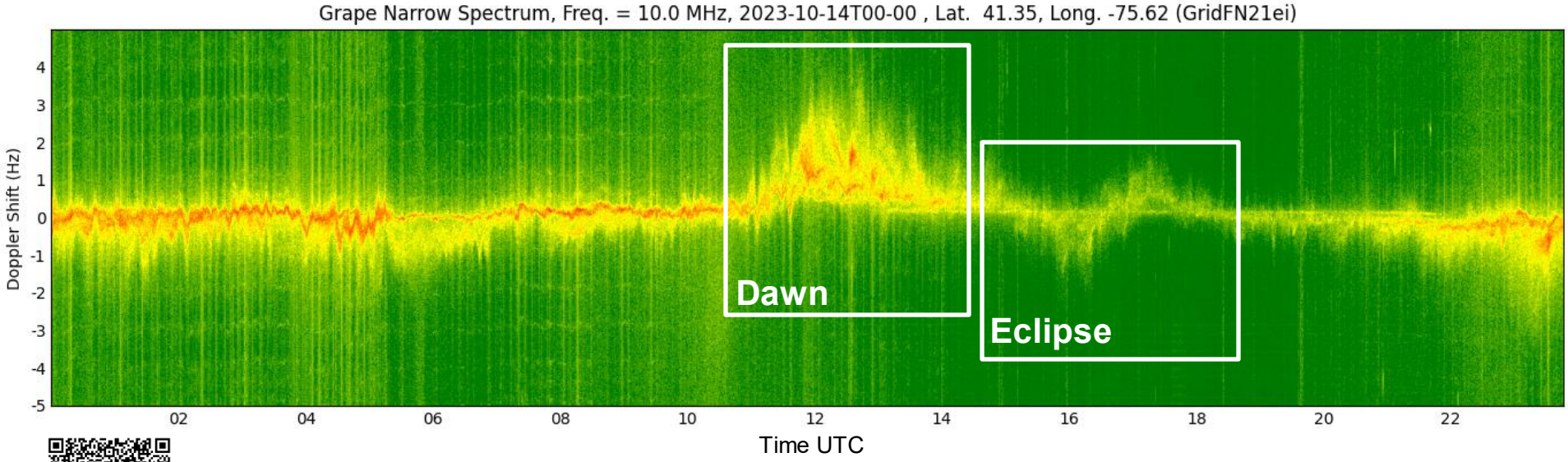
- There is still a legacy Grape1-FLDigi network in operation across the United States.
- These are Grape1-FLDigi Observations of the 14 October 2023 eclipse from the New England Grape Group.



W2NAF 10 MHz Grape1-DRF WWV Doppler

October 14, 2023 Annular Eclipse

W2NAF Receiver near Scranton, PA

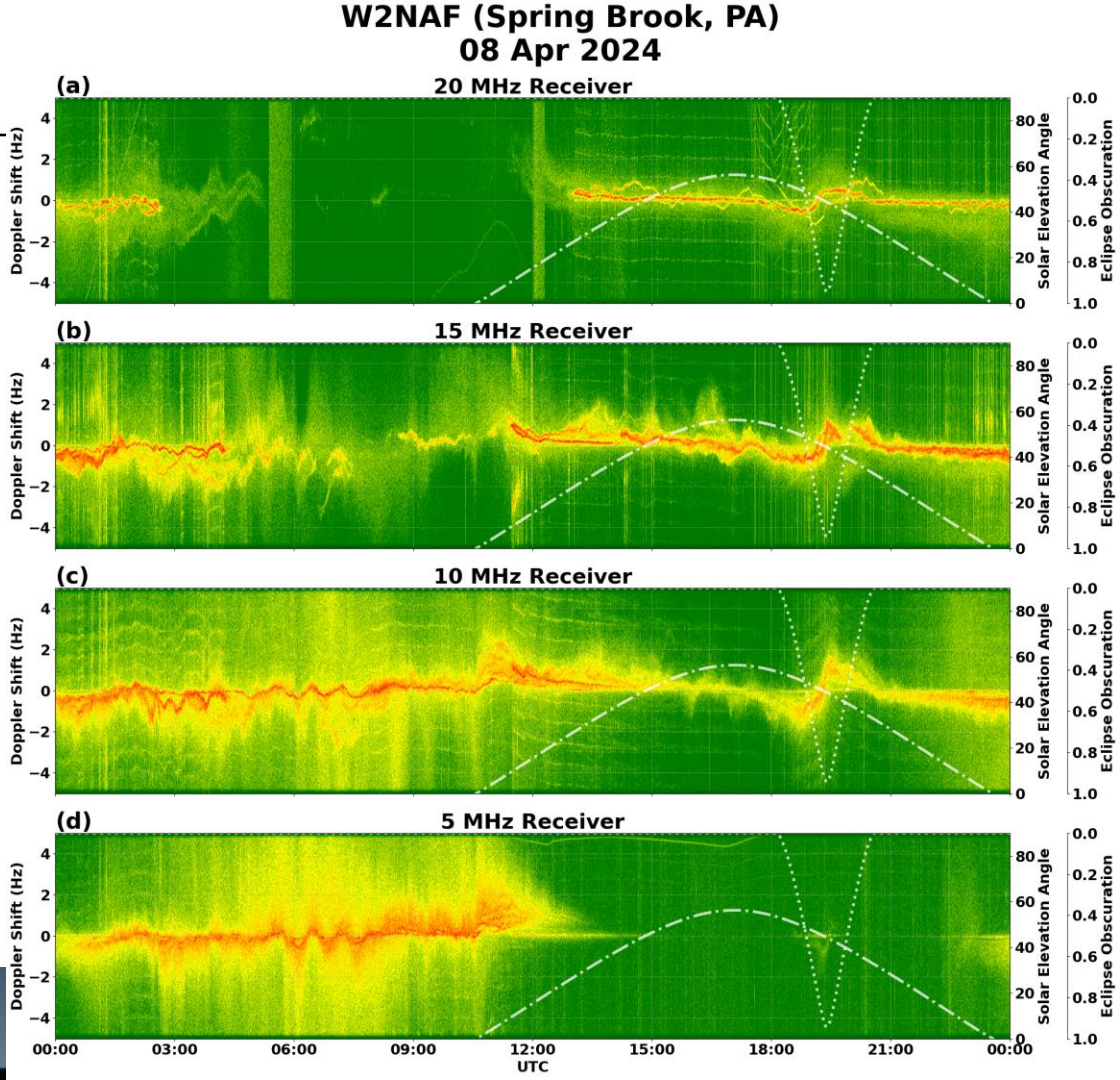


See all Grape1-DRF October 14, 2023 Annular Eclipse Summary Plots

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

WWV → W2NAF

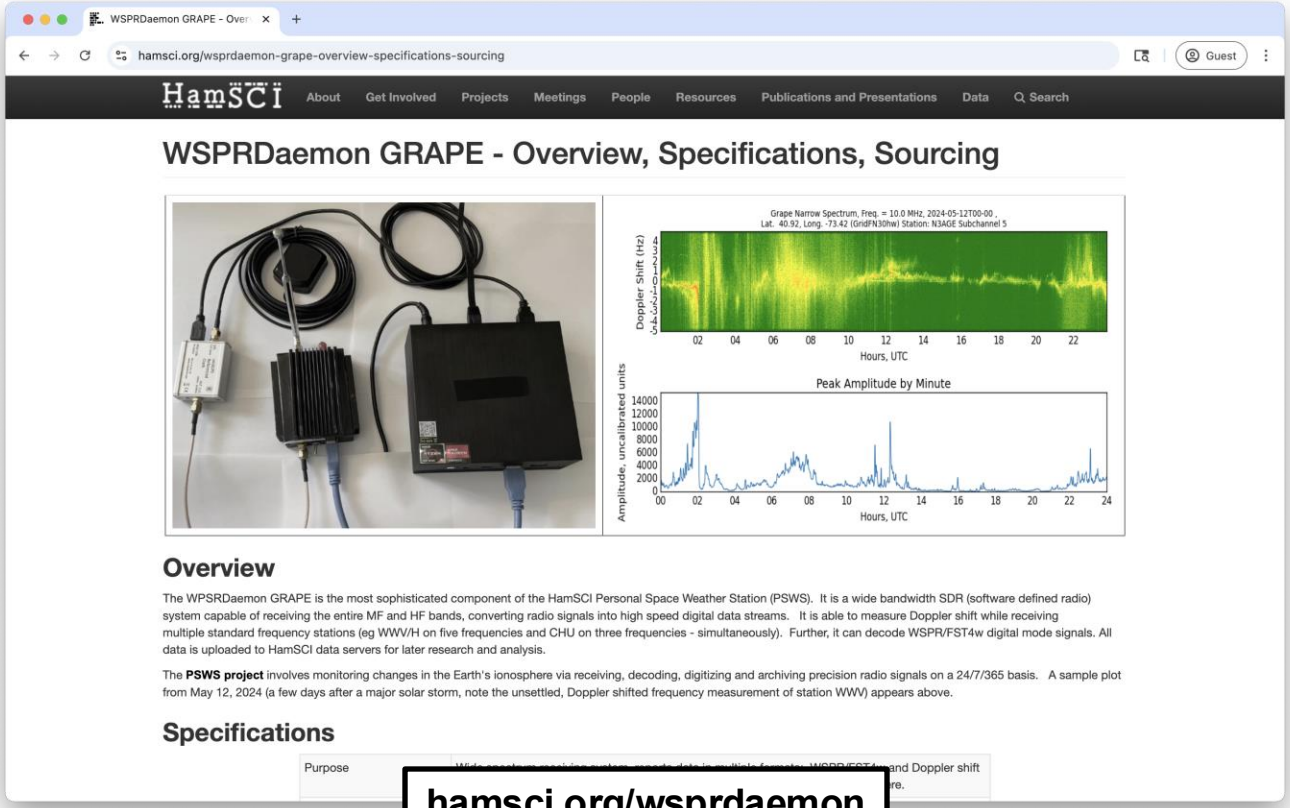
8 April 2024
HF Doppler



Installing and Operating a WSPRDaemon PSWS Receiver

nathaniel.frissell@scranton.edu

WSPRDaemon Grape System



Note: We are still quite experimental, so you will likely need hand-holding along the way with this system! Please reach out to us if you need help setting this up.

nathaniel.frissell@scranton.edu

PSWS Installation at Jenny Jump, NJ

nathaniel.frissell@scranton.edu

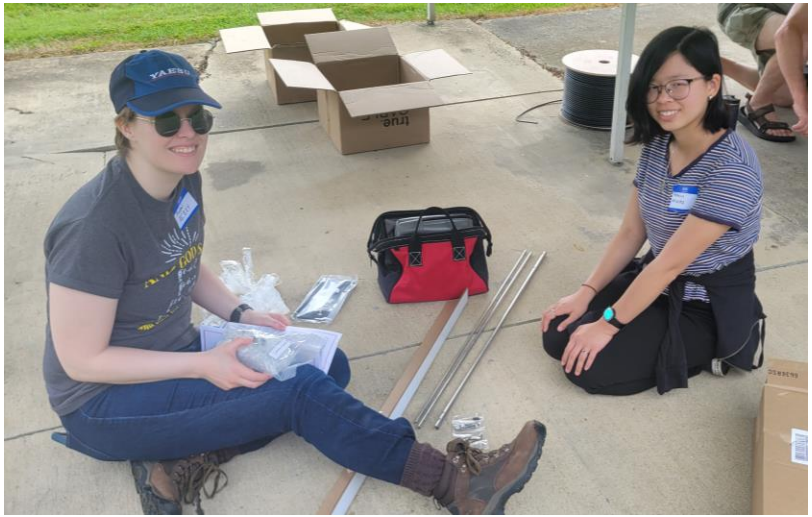
PSWS Installation @ K3LR

nathaniel.frissell@scranton.edu

PSWS Installation @ K3LR

nathaniel.frissell@scranton.edu

Assembling the DXE-RSEAV-1 Active Vertical

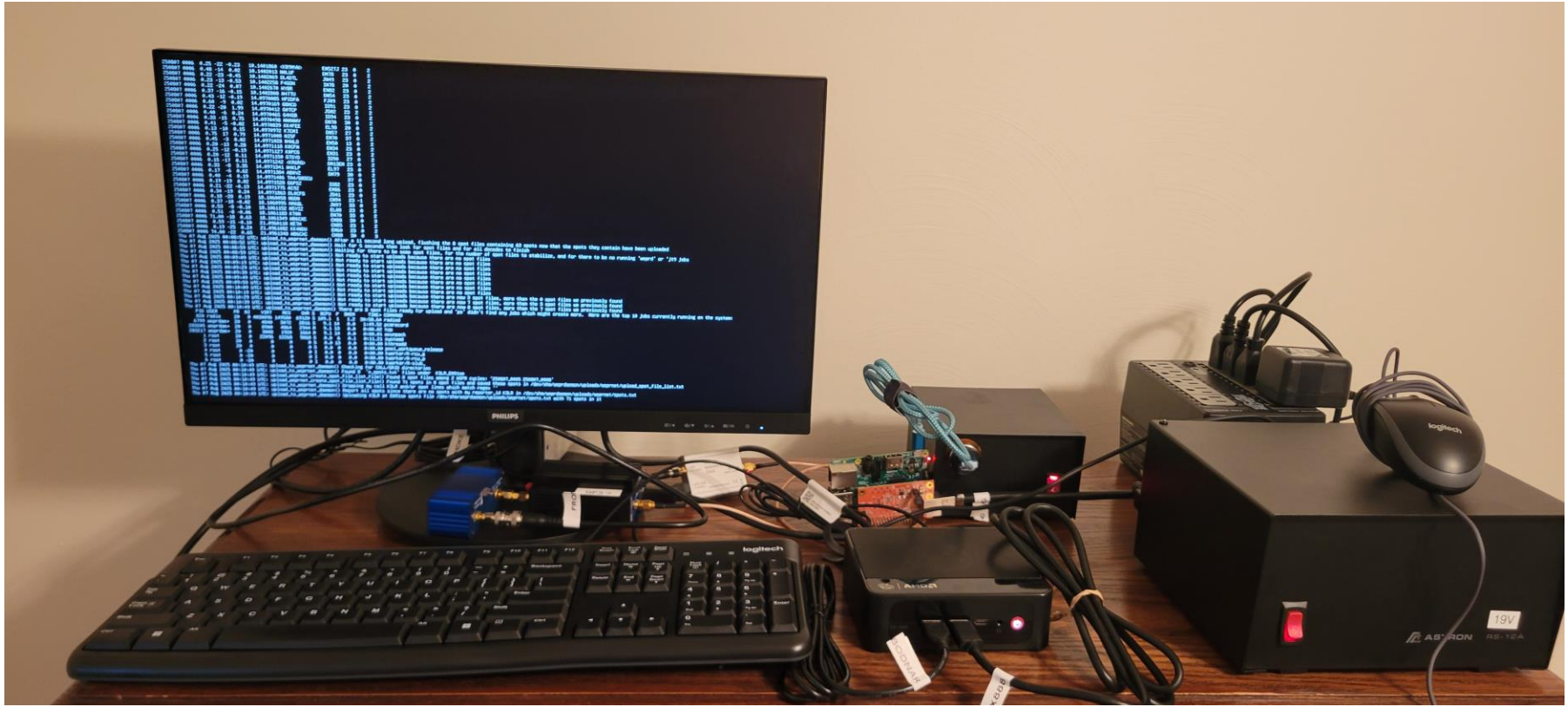


nathaniel.frissell@scranton.edu

Installing the Ground Magnetometer

nathaniel.frissell@scranton.edu

Working PSWS @ K3LR

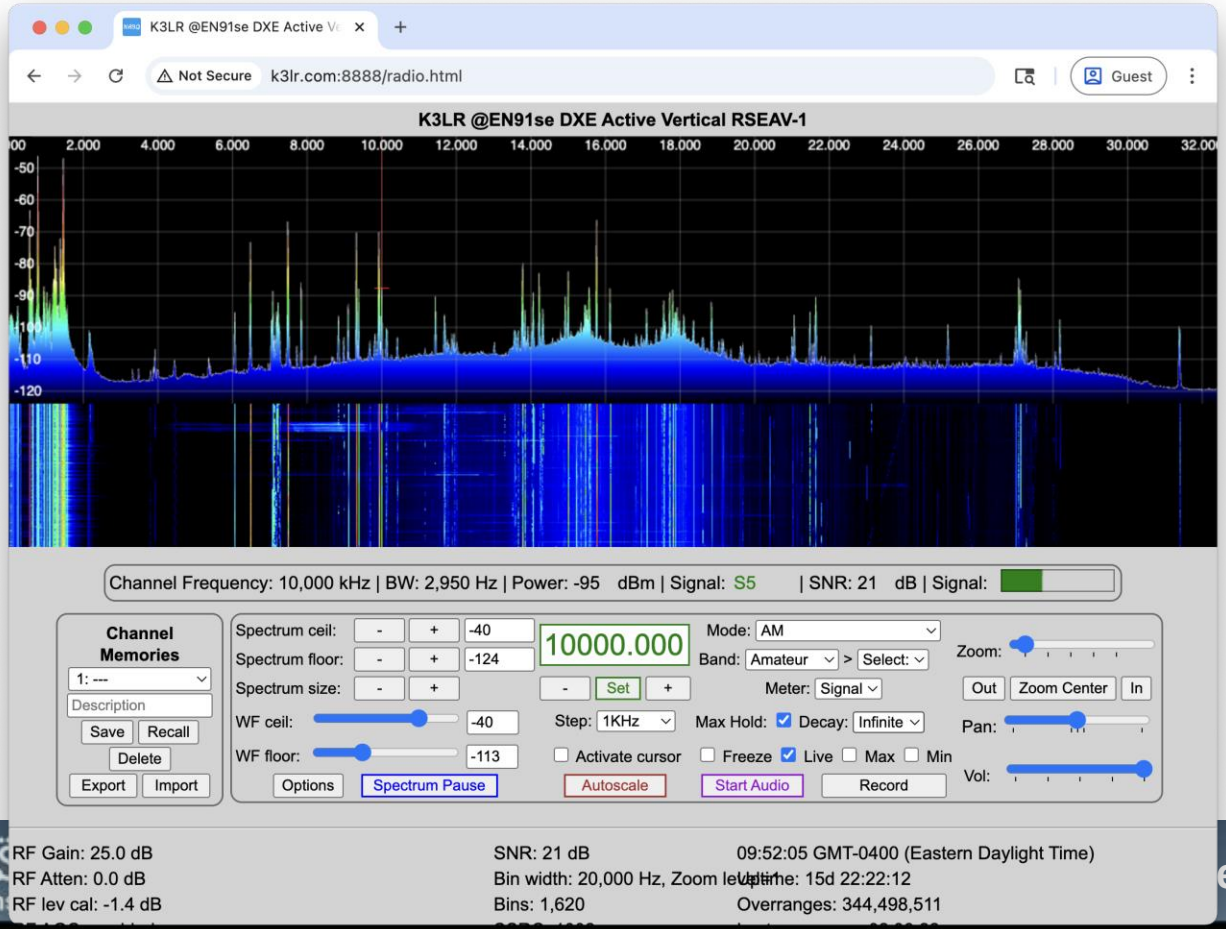


nathaniel.frissell@scranton.edu

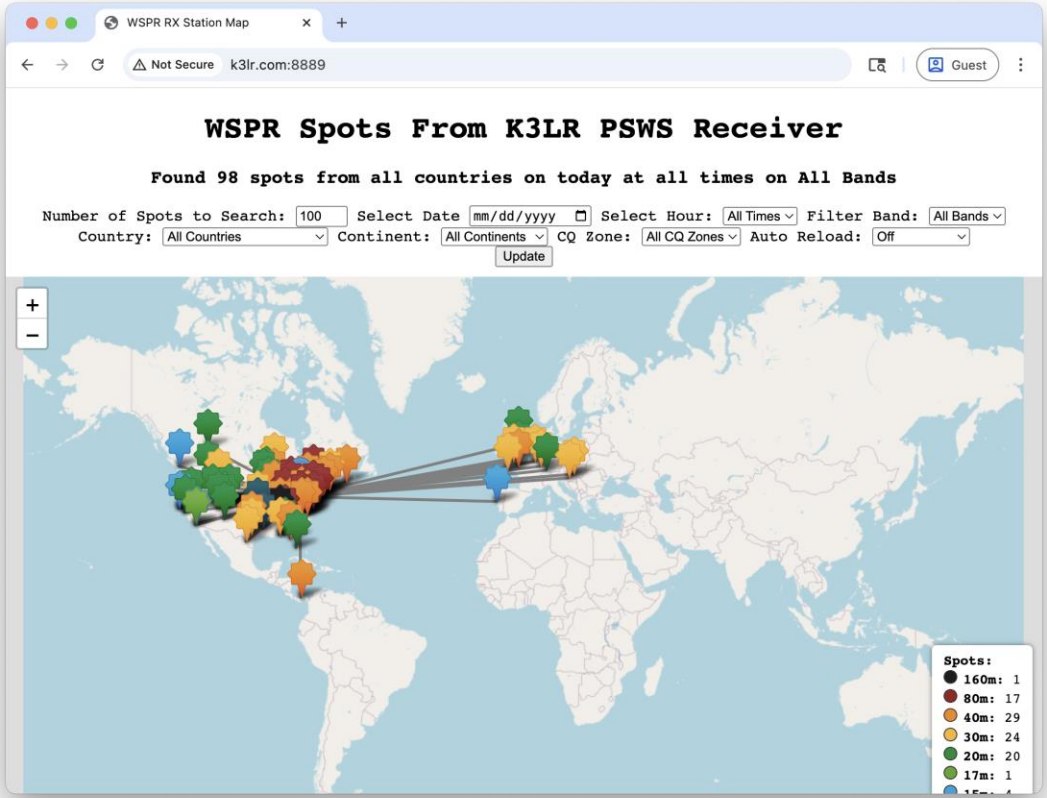
Active Vertical and Magnetometer Installed!

nathaniel.frissell@scranton.edu

KA9Q-Web Interface (Station K3LR)



DXing/Contesting Dashboard (Station K3LR)



Developed by

- Owen Ruzanski KD3ALD

Advised by

- Bud Trench AA3B
- Ray Sokola K9RS
- Andrew Rodland KC2G
- Nathaniel Frissell W2NAF

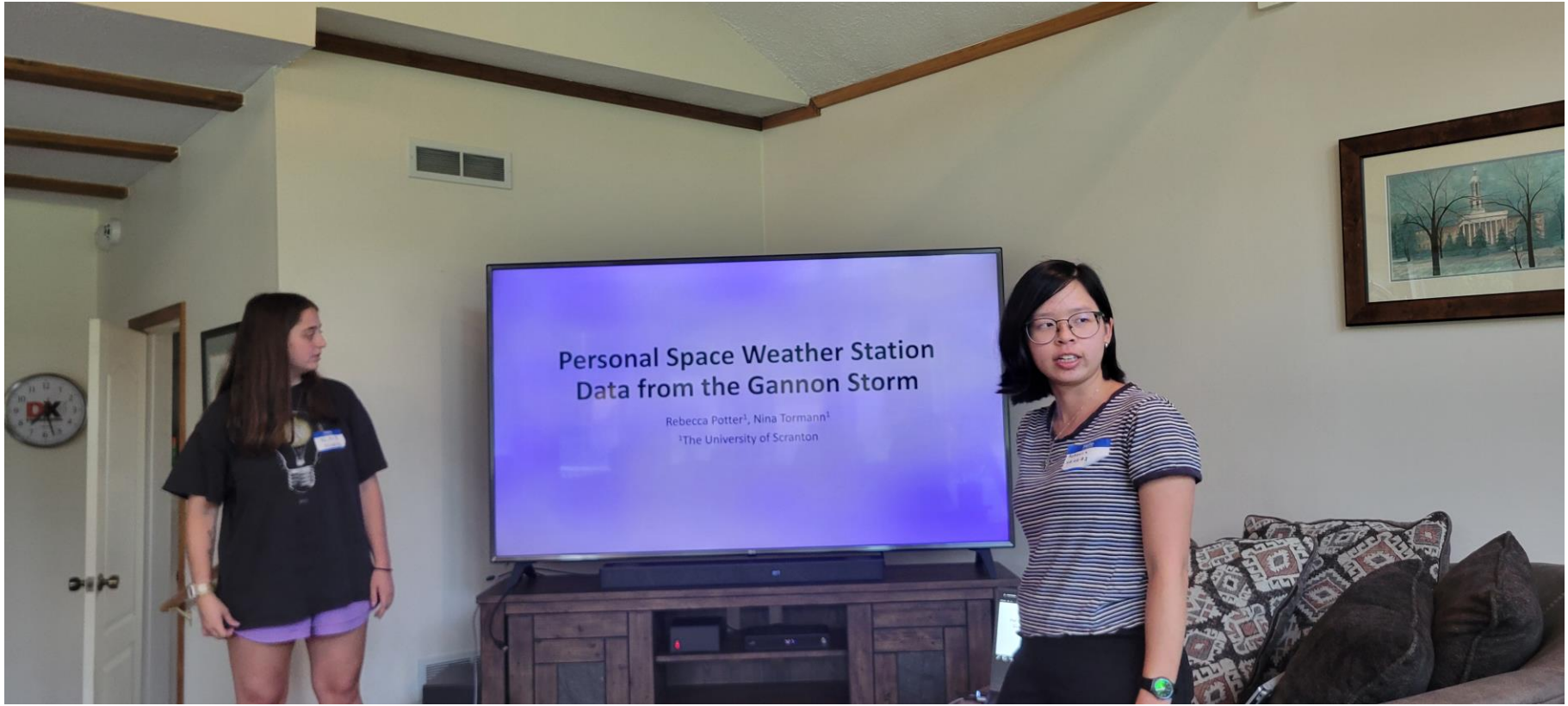
Sponsored by the

Frankford Radio Club

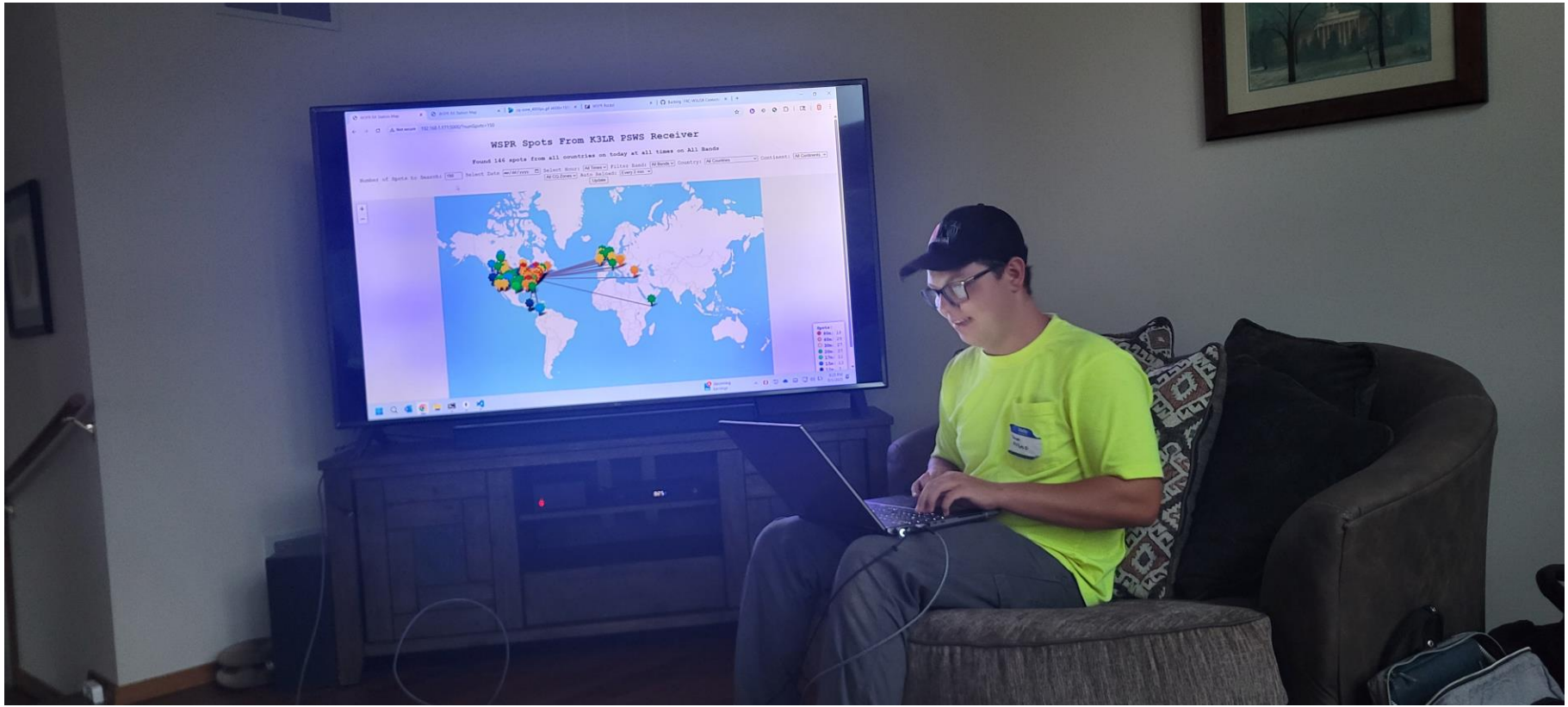
Proficiency Through Competition

nathaniel.frissell@scranton.edu

Nina KD3BJV & Rebecca KE2EBI Geomagnetic Storm Presentation



Owen KD3ALD Contesting Dashboard



nathaniel.frissell@scranton.edu

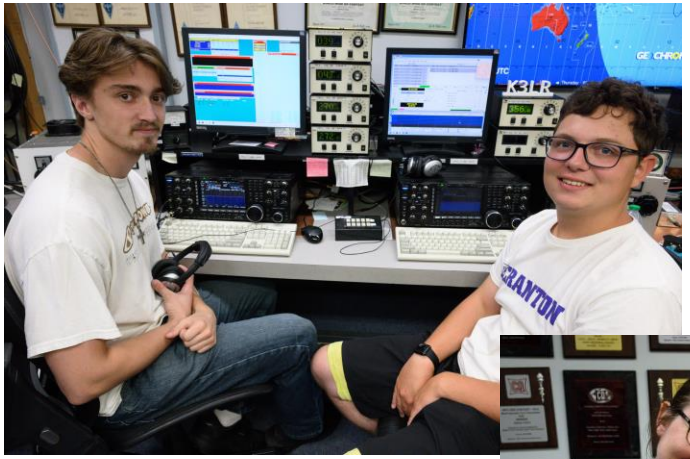
Kristina KD8OXT Open Space Presentation

nathaniel.frissell@scranton.edu

Tour & Operating @ K3LR

nathaniel.frissell@scranton.edu

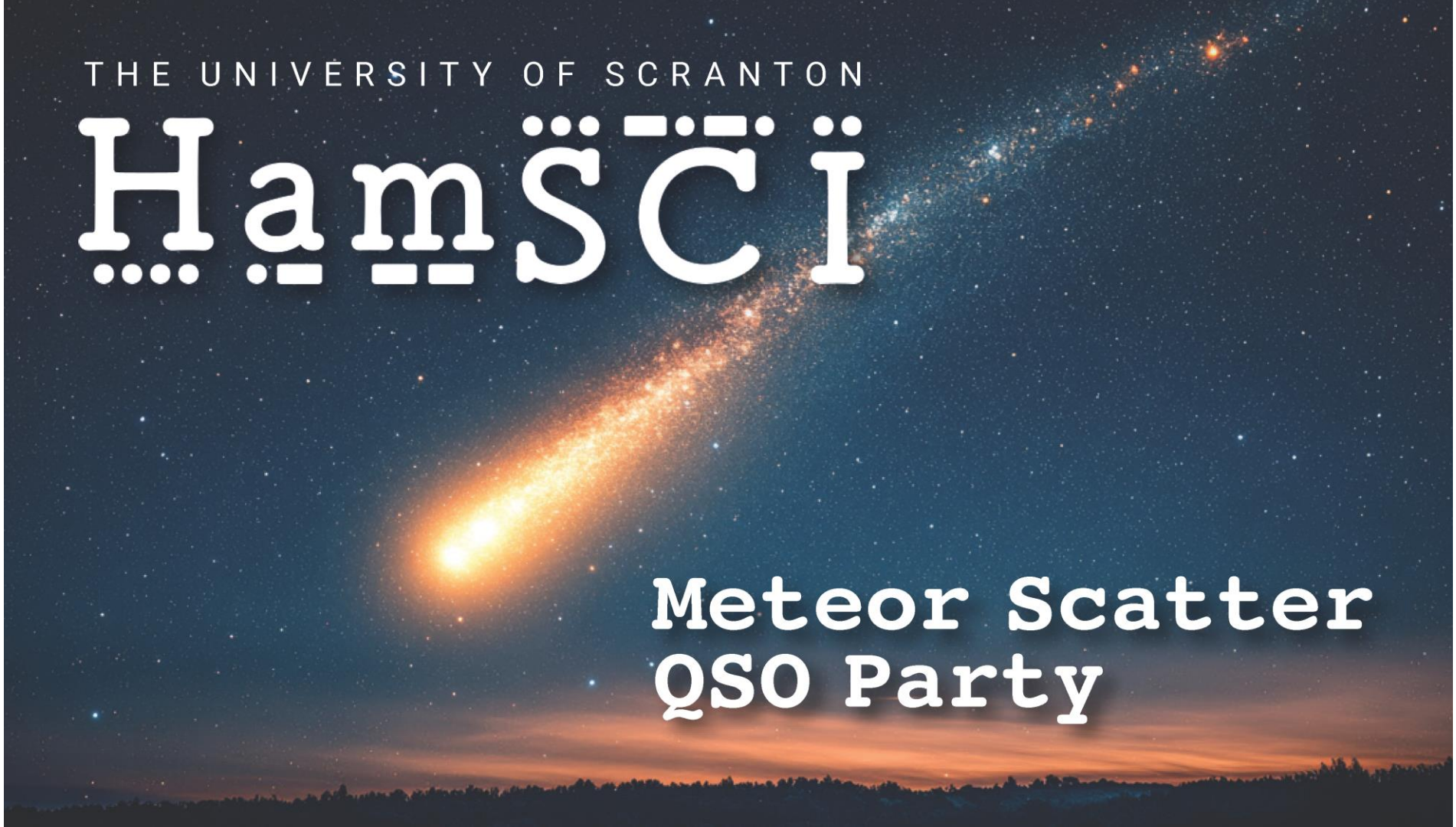
Operating @ K3LR



nathaniel.frissell@scranton.edu

PSWS Installation Team @ K3LR

nathaniel.frissell@scranton.edu


THE UNIVERSITY OF SCRANTON
HamSCI
Meteor Scatter
QSO Party

Work the rocks! Decode the pings!

Contribute to science as we strive to uncover the secrets of meteor scatter propagation.

Join hundreds of operators on 6 and 10 meter MSK144 during the Perseid and Gemini meteor showers.

scan here

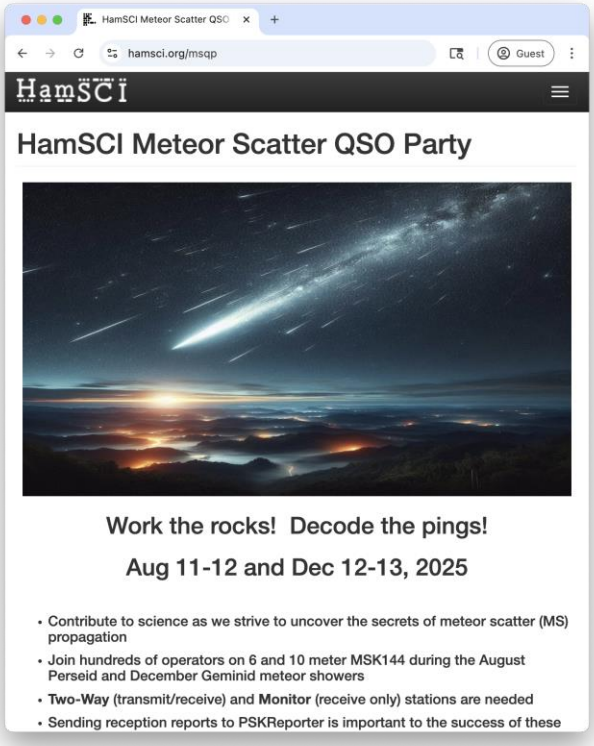
to learn more

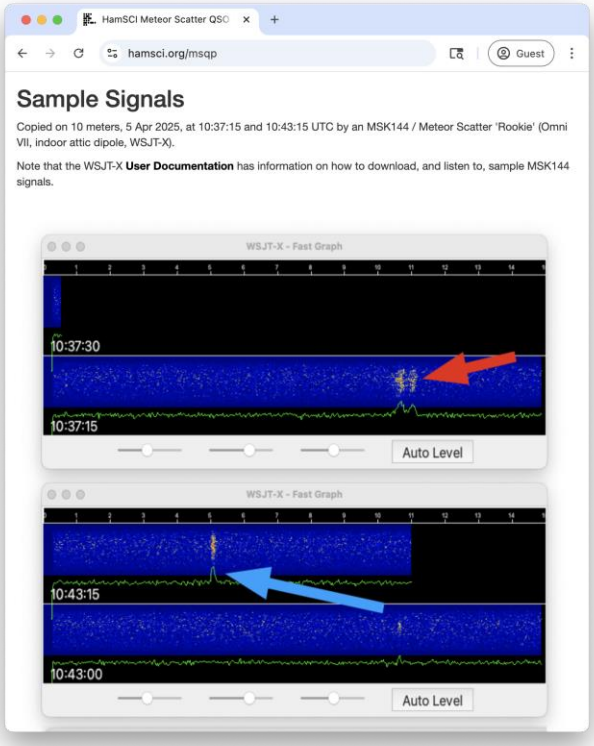
Transmit & Monitor stations needed

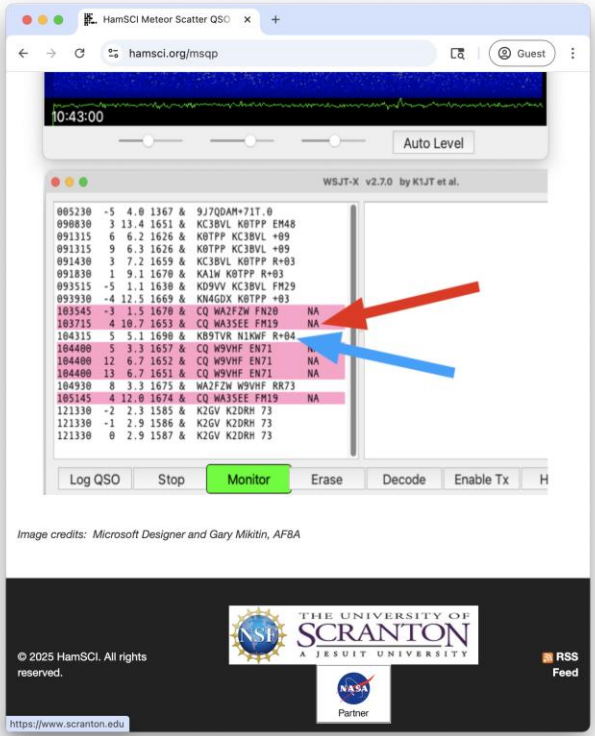
Aug 11-12 & Dec 12-13,2025

hamsci.org/msqp

Visit hamsci.org/msqp to get started!



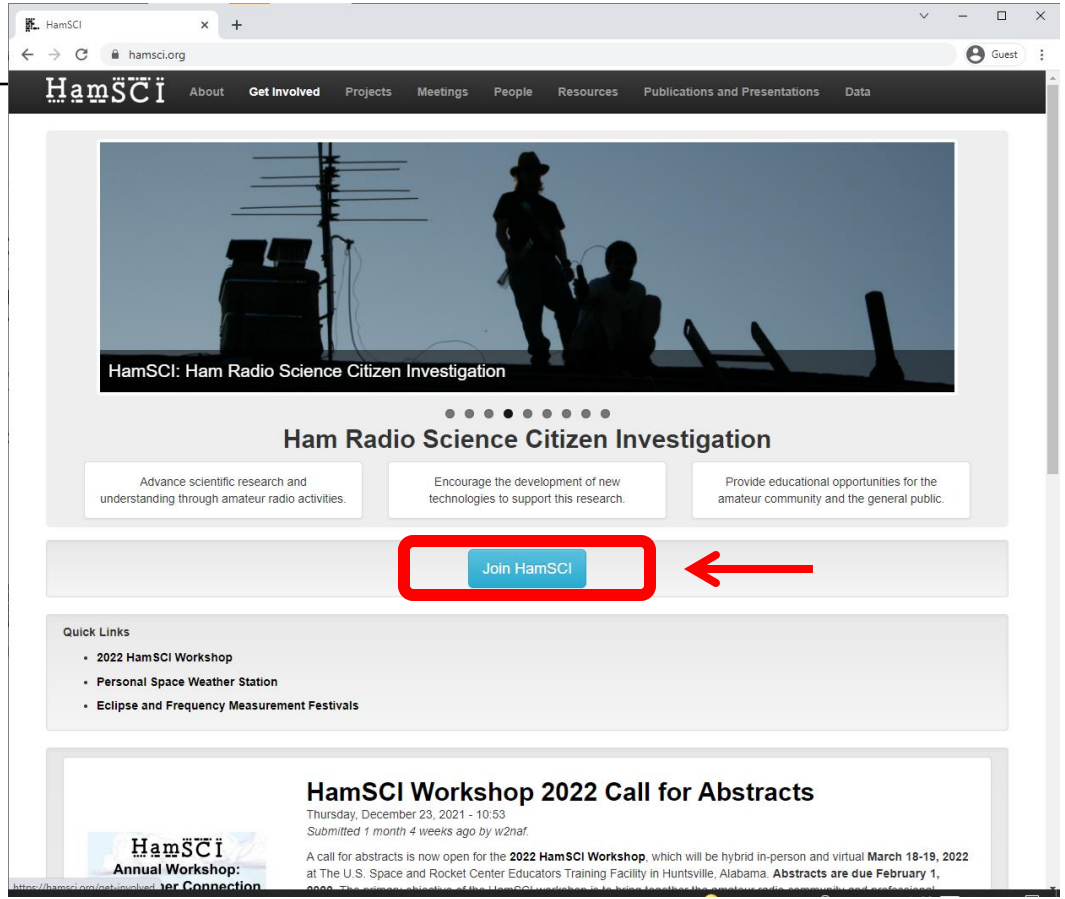




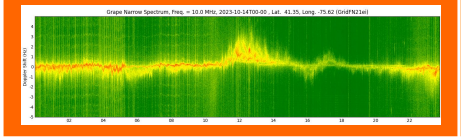
nathaniel.frissell@scranton.edu

Getting Involved

- **HamSCI now has over 1400 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!



HamSCI Zoom Telecons

TAPR-HamSCI Technical Session	**Joint TAPR-HamSCI engineering telecon to discuss design of new instrumentation.**	**Mondays at 9 PM Eastern (Tuesdays 0100 UTC during DST)**
PSWS Technical Session 	**Telecon to support operations of the HamSCI Personal Space Weather Station**	**Thursdays at 10 AM Eastern (1400 UTC during DST)**
HamSCIence Telecon	**Science Seminar Series and general telecon to support HamSCI's Mission.**	**Thursdays at 4 PM Eastern (2000 UTC during DST)**

Zoom links and calendar at http://hamsci.org/get-involved.

Thank you!

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 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.

nathaniel.frissell@scranton.edu

Backup Slides

nathaniel.frissell@scranton.edu

Find out more…

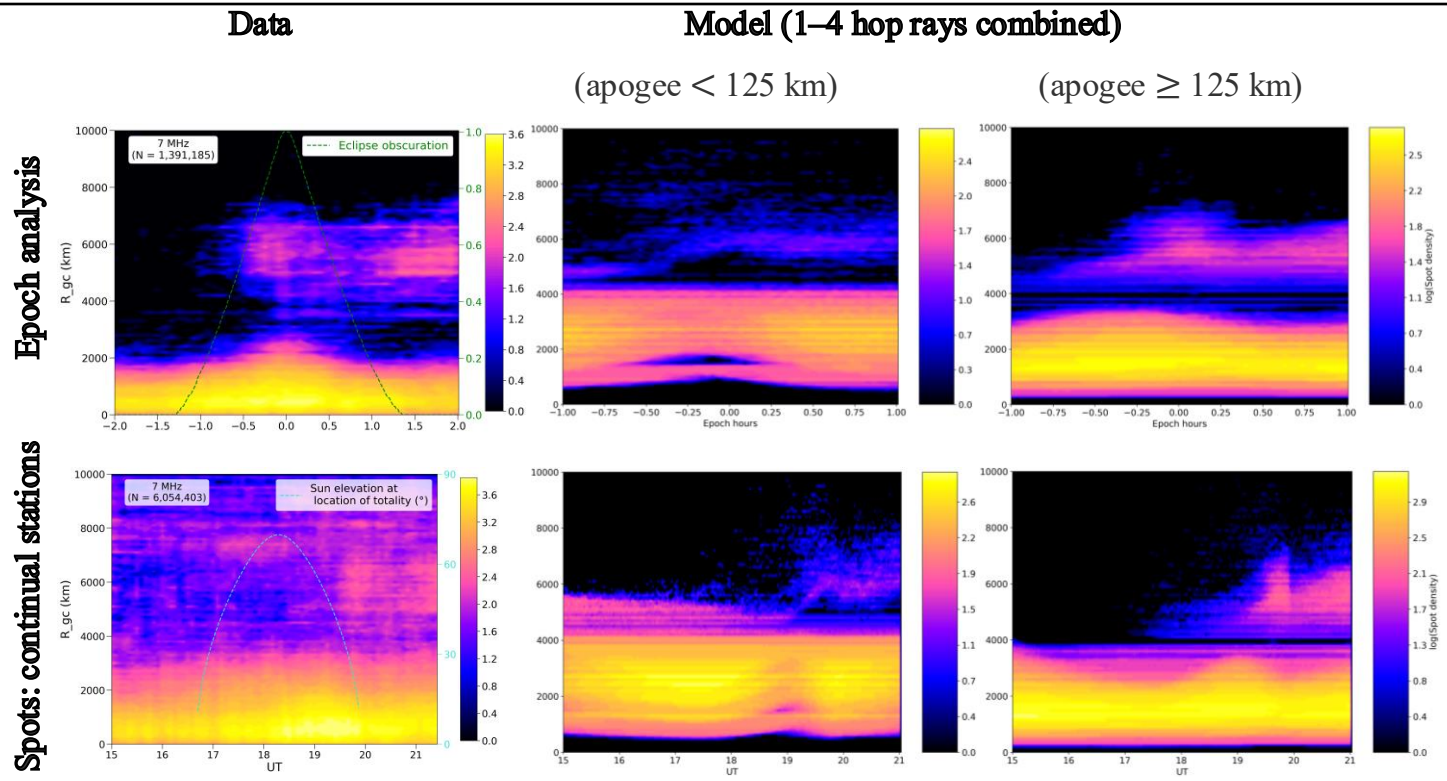
hamsci.org

hamsci@hamsci.org

facebook.com/HamSCI

www.rsgb.org

Comparison: 7 MHz Data & WaccmX-SAMI3



Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology

Whistler Catcher
Very Low Frequency (VLF)

https://hamsci.org/psws

nathaniel.frissell@scranton.edu

Whistler Catcher VLF Reception System

Developed by Jonathan Rizzo KC3EEY

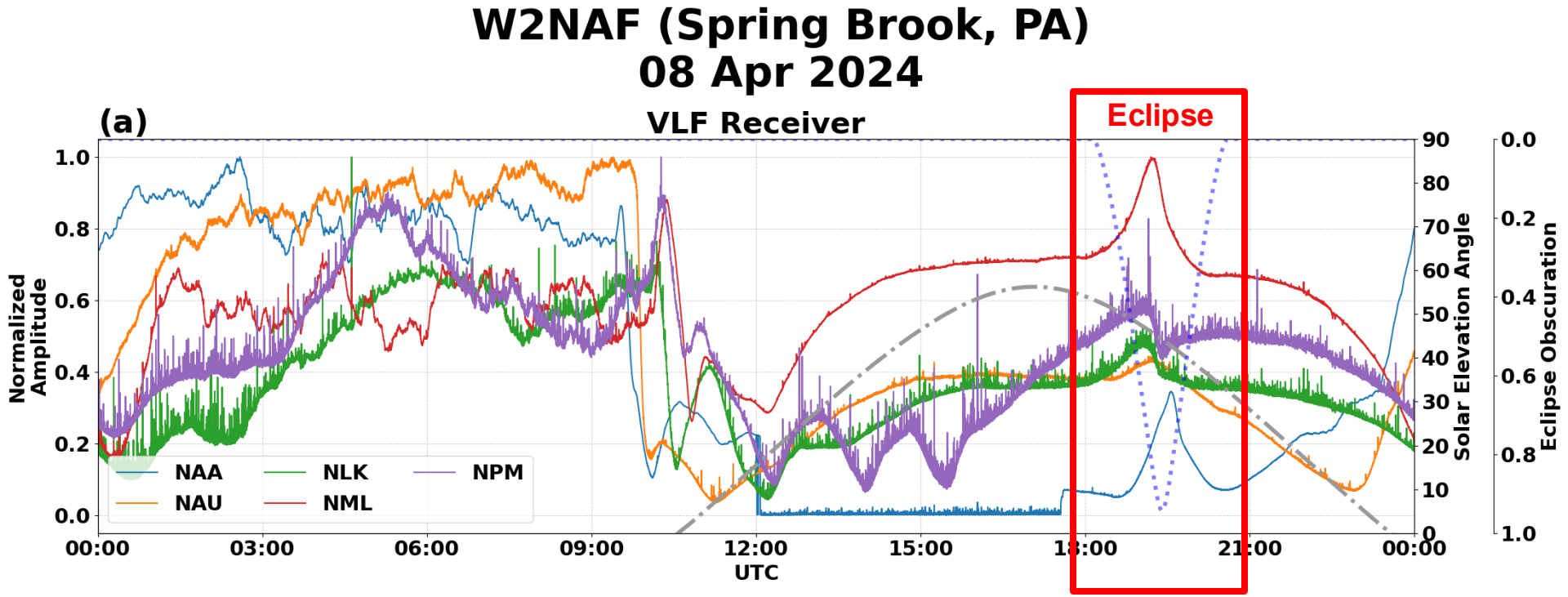
Purpose

- A VLF Reception System for purposes of capturing Natural Radio emissions, Sudden Ionospheric Disturbances in VLF transmitters, and VLF amateur transmissions.

System Components

- VLF Active Antenna consisting of an E-field probe antenna element and preamp.
- Backend System Signal Processor to capture and analyze the VLF spectrum.
- GNSS receiver provides frequency and timestamping reference.
- vlfrx-tools software used for all signal capture, processing, and recording, including natural radio event detection.

W2NAF/KC3EEY VLF Receiver 8 April 2024



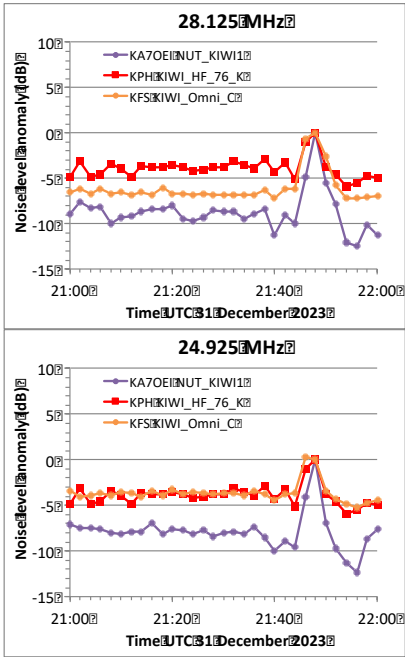
nathaniel.frissell@scranton.edu

Exchanges online with HamSCI scientists

From Dr Phil Erickson W1PJE, Director MIT Haystack Observatory

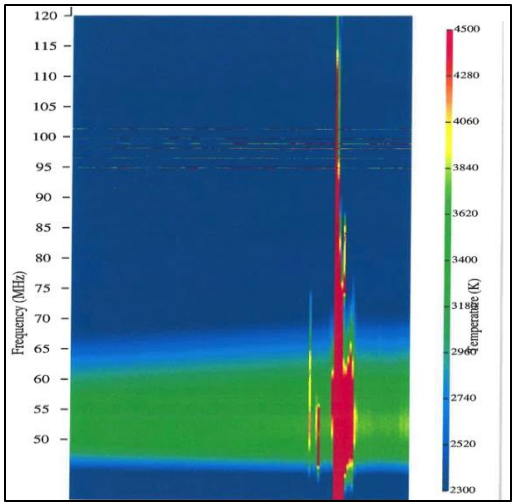
Hi Gwyn…,

You mentioned: "what may be a solar noise burst." *My distinguished colleague Dr. Alan EE Rogers … operates the precisely calibrated EDGES system … So I asked Alan and sure enough, on 31 December 2023, the system caught a spectacular radio burst signature associated with the X5 solar flare.*



Noise level anomalies from uncalibrated KiwiSDRs with 21:48 UTC at 0dB.

Noise Temperature Spectrum 40-120MHz from EDGES system courtesy Dr Alan Rogers, MIT



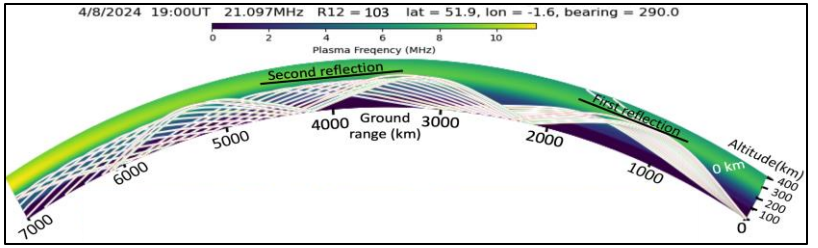
Mutual learning with an MSc student: PyLap

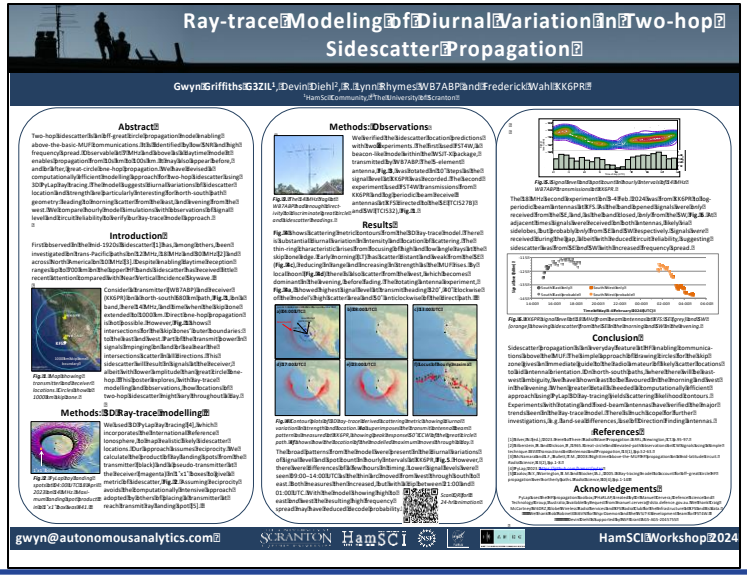
HamSCI's Nathaniel Frissell W2NAF began PyLap, a Python wrapper for the PHaRLAP ray-tracing toolbox, as a project with an Undergrad then Masters students.

Devin Diehl, a Software Engineering Masters student, took on the project. He taught me how to use PyLap, then how to add my own calculations.

My investigations with PyLap of two-hop sidescatter propagation gave Devin a novel use-case for his studies.

Using WSPR spots from an experiment with two radio amateurs WB7ABP and KK6PR we presented results in this poster at HamSCI 2024.



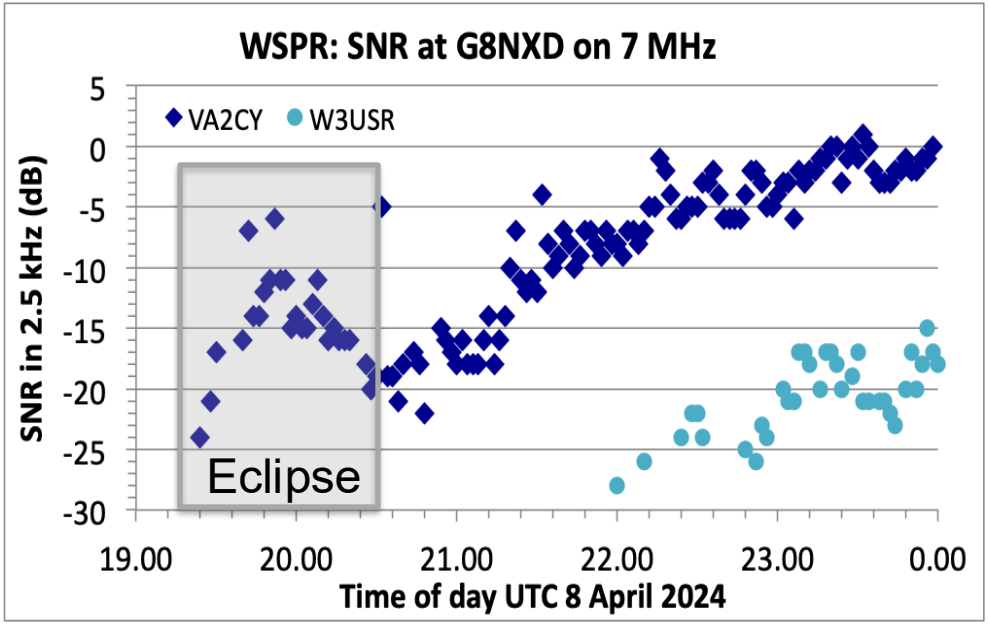


Finding data from amateurs for researchers

Dr Kuldeep Pandey, a Postdoctoral Researcher at New Jersey Institute of Technology, is active in HamSCI. One of his studies models changes in absorption on 7 MHz during the 8 April 2024 eclipse.

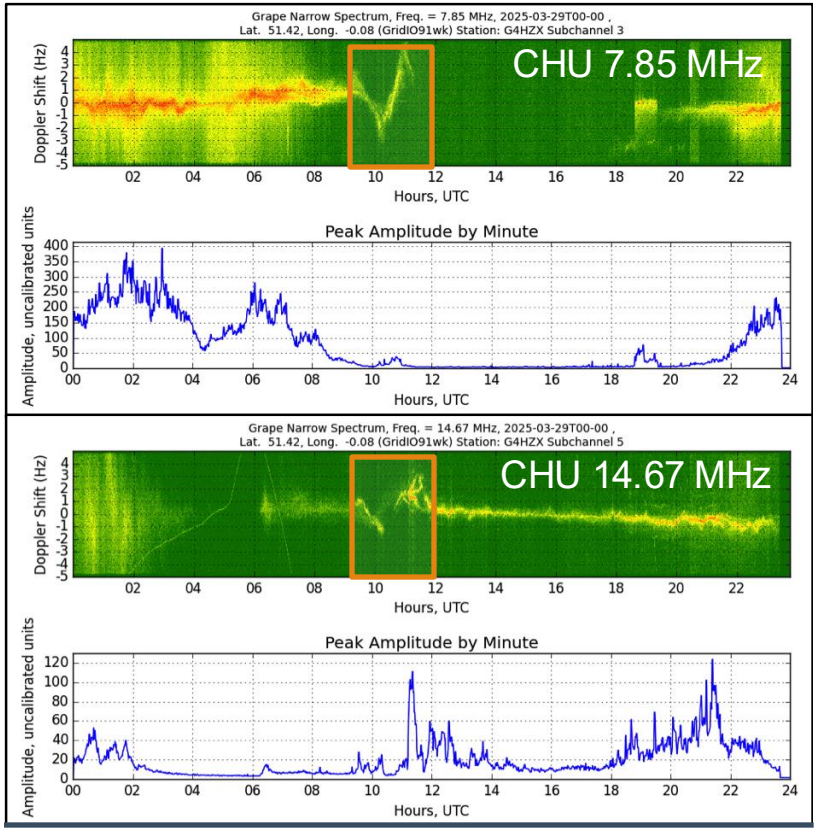
I found a nice example for Kuldeep of 7 MHz opening much earlier than normal on eclipse day for transatlantic WSPR transmissions from Bernard VA2CY received by Mike G8NXD.

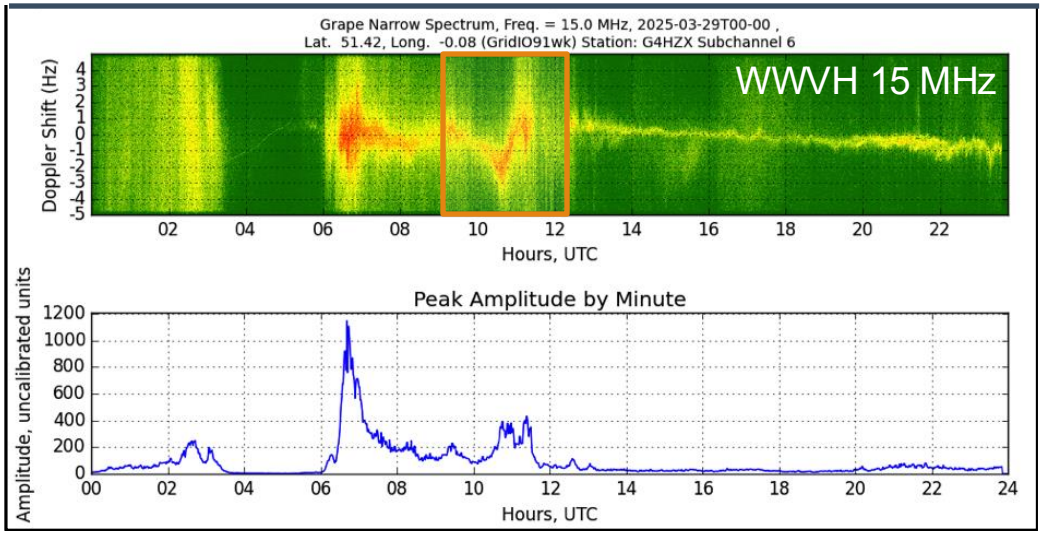
The SNR rose as the eclipse reduced D region absorption, then fell, before rising as the band opened ‘normally’.



VA2CY, nr Quebec, to G8NXD, Cornwall, a 4700 km path

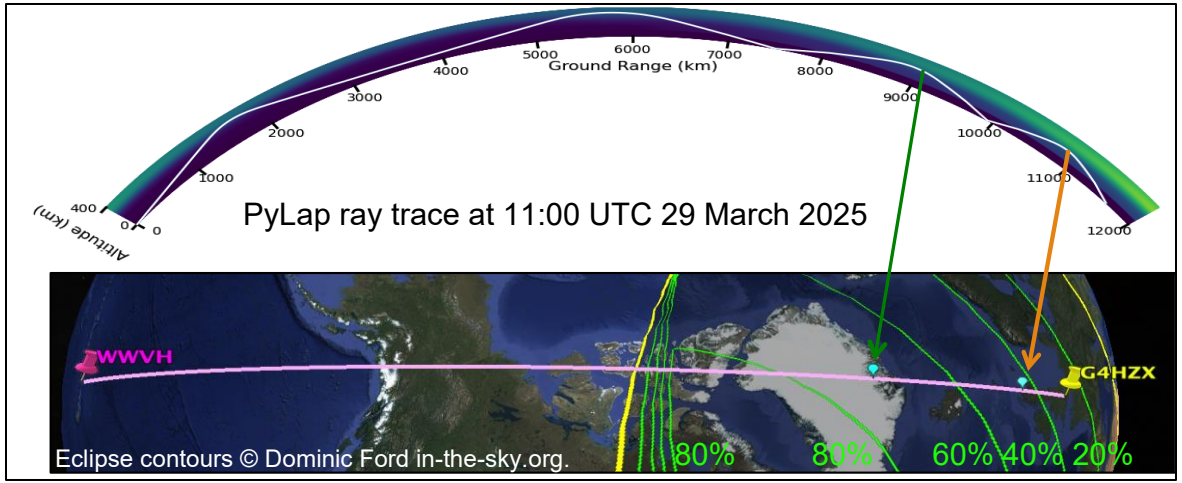
March ‘25 Eclipse HamSCI Grape in London

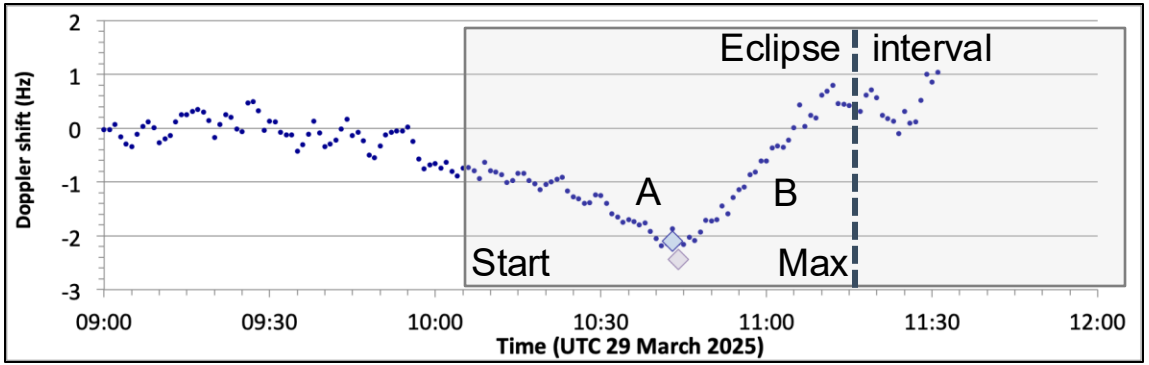




Using an RX888 SDR as a WsprDaemon Grape and reporting to the HamSCI Personal Space Weather Station database these Doppler spectrograms come from Nigel, G4HZX South London.

March ‘25 Eclipse: 15 MHz WWVH to G4HZX





This is my current project…

PyLap ray tracing shows where the WWVH signal was reflected in the eclipse’s path over East Greenland and off NW Scotland.

Negative Doppler arose, in part, from the height of reflection rising as the eclipse developed.

One of several questions: Why is slope B greater than slope A?

W2NAF Ham Radio Station Near Scranton, PA

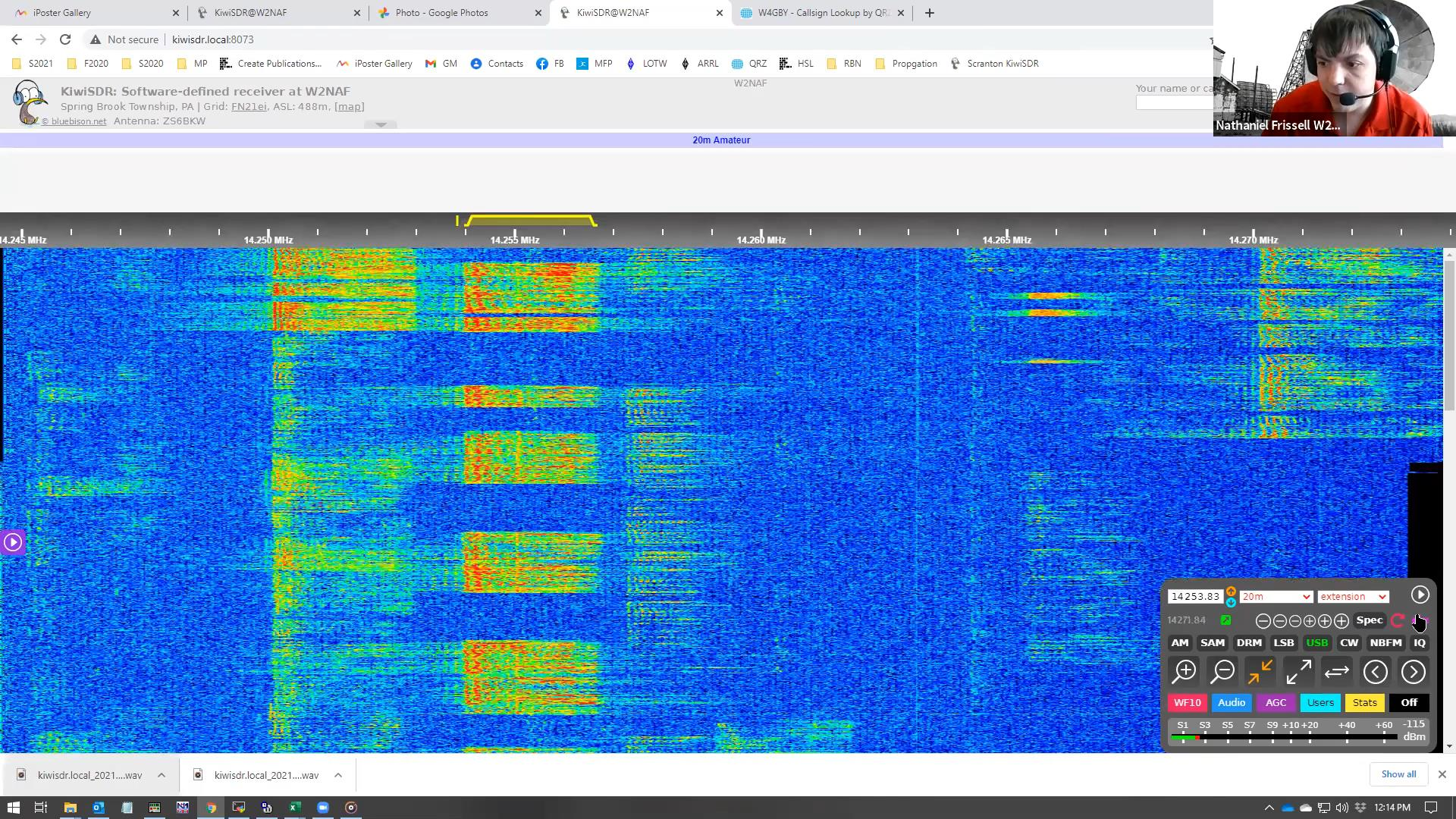
nathaniel.frissell@scranton.edu

W2NAF Ham Radio Station Near Scranton, PA

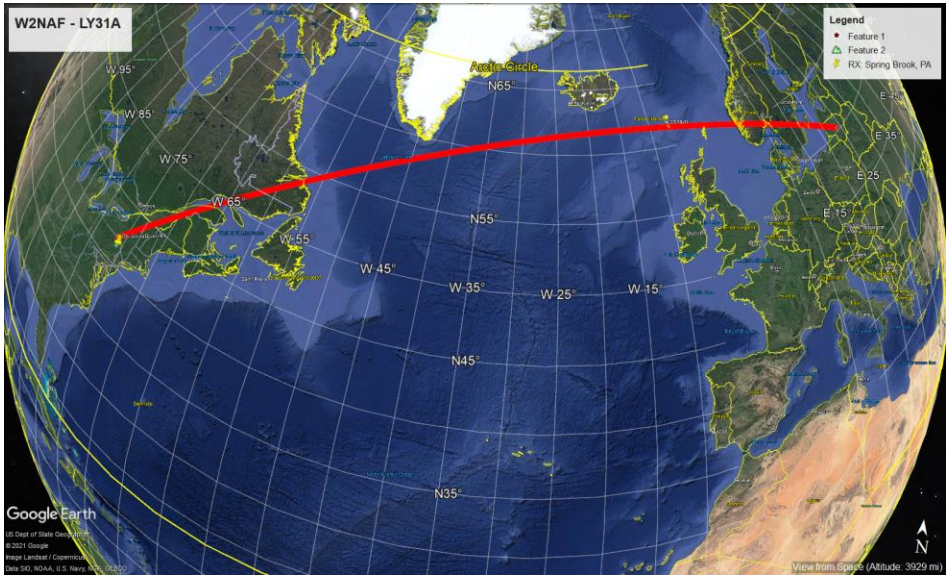
nathaniel.frissell@scranton.edu

W2NAF Ham Radio Station Near Scranton, PA

nathaniel.frissell@scranton.edu

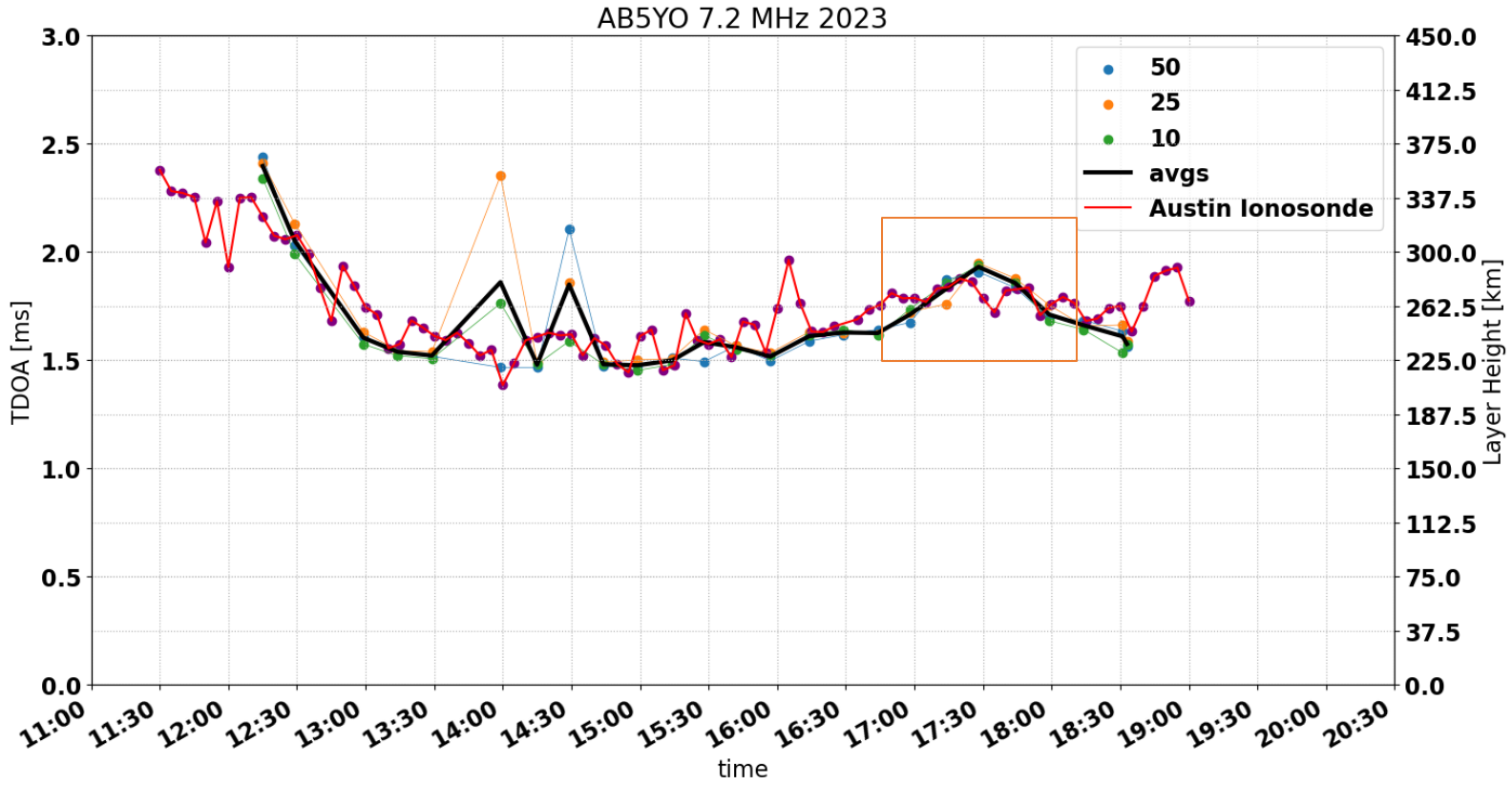

iPoster Gallery
KiwiSDR@W2NAF
Photo - Google Photos
KiwiSDR@W2NAF
W4GBY - Callsign Lookup by QR
Not secure
kiwisdr.local:8073
S2021
F2020
S2020
MP
Create Publications...
iPoster Gallery
GM
Contacts
FB
MFP
LOTW
ARRL
QRZ
HSL
RBN
Propgation
Scranton KiwiSDR
W2NAF
KiwiSDR: Software-defined receiver at W2NAF
Spring Brook Township, PA | Grid: FN21ei, ASL: 488m, [map]
© bluebison.net Antenna: ZS6BKW
Your name or ca
Nathaniel Frissell W2...
20m Amateur
14.245 MHz
14.250 MHz
14.255 MHz
14.260 MHz
14.265 MHz
14.270 MHz
14253.83
20m
extension
14271.84
Spec
AM
SAM
DRM
LSB
USB
CW
NBFM
IQ
WF10
Audio
AGC
Users
Stats
Off
S1 S3 S5 S7 S9 +10 +20 +40 +60 -115
dBm
kiwisdr.local_2021....wav
kiwisdr.local_2021....wav
Show all
12:14 PM

LY31A (Lithuania)



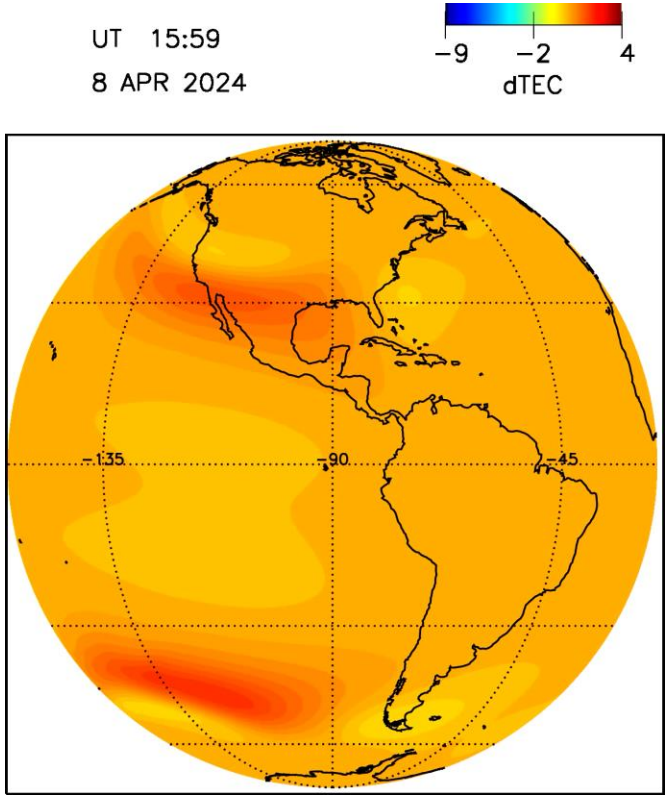
4200 miles (6800 km)

Results 14 October 2023 9 km Path 7.2 MHz



alexandros.papadopoulos@scranton.edu
nathaniel.frissell@scranton.edu

Ionospheric Model of 8 April 2024 Total Eclipse



SAMI3-HWM Model Run
By Joseph Huba

THE UNIVERSITY OF SCRANTON
A JESUIT UNIVERSITY

CASE WESTERN RESERVE UNIVERSITY

NJIT New Jersey Institute of Technology

MIT HAYSTACK OBSERVATORY

TAPR

NSF

ARDC AMATEUR RADIO DIGITAL COMMUNICATIONS

NASA Partner

nathaniel.frissell@scranton.edu

Quiz Question!

What well-publicized astronomical events took place over North America on October 14, 2023, and April 8, 2024?

Quiz Question!

What well-publicized astronomical events took place over North America on October 14, 2023, and April 8, 2024?

Photo by Ann Marie Rogalcheck-Frissell, KC2KRQ

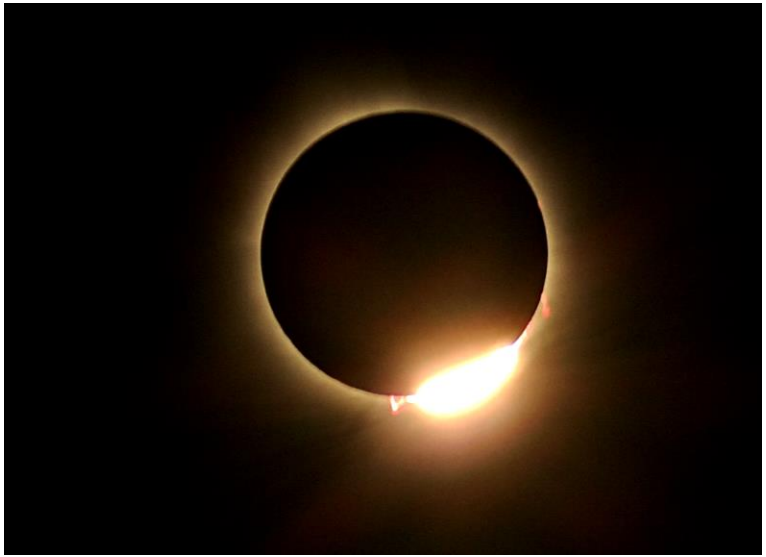


Photo by Michael Hauan, AC0G

PSWS Teams

University of Scranton
- **Nathaniel Frissell W2NAF (PI)**
- Devin Diehl
- Rachel Frissell W2RUF
- Cuong Nguyen KC3UAX
- Gerard Piccini KC3ZHK
- Veronica Romanek KC2UHN
- Jonathan Rizzo KC3EEY
- Simal Sami KC3UAW
- Bob Spalletta KC3QOB
- Nisha Yadav
- Bob McGwier N4HY

Responsibilities
- Lead Institution
- HamSCI Lead
- Radio Science Lead

TAPR & Friends
- Tom McDermott N5EG
- John Ackerman N8UR
- David Witten KD0EAG (Magnetometer)
- Jules Madey K2KGJ (SK) (Magnetometer)
- David Larsen KV0S
- Phil Karn KA9Q
- Rob Robinett AI6VN
- Glenn Elmore

University of Alabama
- **Bill Engelke AB4EJ (Chief Architect)**
- Travis Atkison (PI)

Responsibilities
- Central Database
- Central Control Software
- Local Control Software

Case Western Reserve University
Case Amateur Radio Club W8EDU
- **Kristina Collins KD8OXT**
- **David Kazdan AD8Y**
- **John Gibbons N8OBJ**
- Christian Zorman (PI)
- Rachel Boedicker AC8XY
- Skylar Dannhoff KD9JPX
- Aidan Montare KB3UMD

Responsibilities
- Low Cost PSWS System

MIT Haystack Observatory
- **Phil Erickson W1PJE**

Dartmouth College
- David McGaw N1HAC

New Jersey Institute of Technology
- **Hyomin Kim KD2MCR (PI)**
- Gareth Perry KD2SAK
- Diego Sanchez KD2RLM
- Andy Gerrard KD2MCQ

Responsibilities
- Ground Mag Oversight & Testing
- Science Collaborators

Ground Magnetometer

Developed by TAPR and NJIT

Purpose

- To establish a densely-spaced magnetic field sensor network to observe Earth's magnetic field variations in three vector components.

Target performance level

- ~10 nT field resolution
- 1-sec sample rate (note: Earth's magnetic field ranges from 25,000 to 65,000 nT)
- Total cost ~$100-$150

Sensors

- PNI RM3100 magnetometer module
  - 3 axis magneto-inductive measurement module
  - Very small (25.4 x 25.4 x 8 mm)
- MCP9808 temperature sensor

Now available from TAPR!

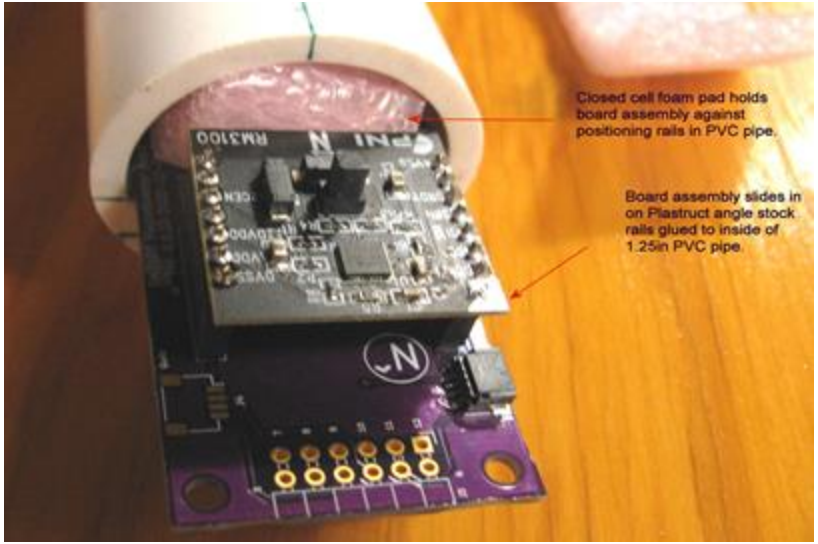


Photo by Jules Madey, K2KGJ

Comparison: 21 MHz Data & SAMI3

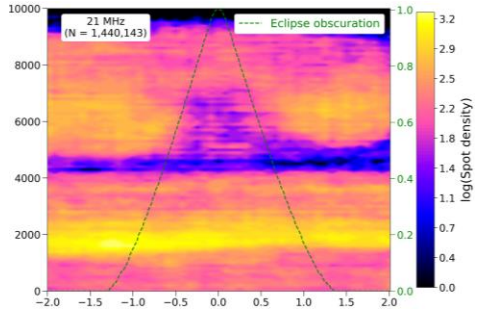
Data

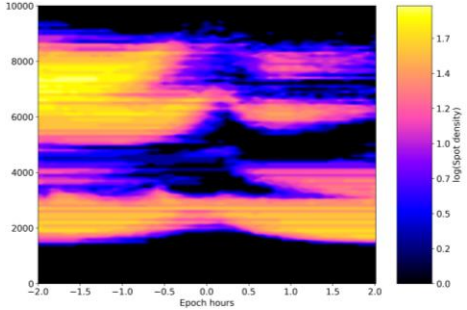
Model (1–4 hop rays combined)

(apogee < 125 km)

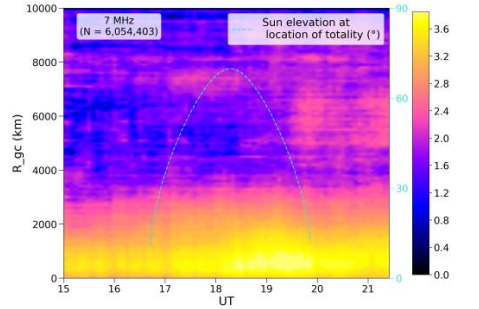
(apogee ≥ 125 km)

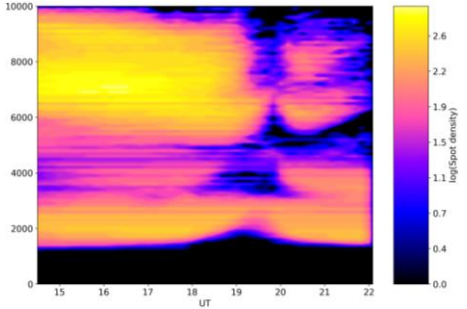
Epoch analysis





Spots: continual stations





Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology

2024 Solar Eclipse QSO Party Summary

Ham radio links within CONUS (range < 4000 km)

- 1.8 - 7 MHz (160 - 40 m): increase in range of communications, symmetric response to eclipse
- 14 - 28 MHz (20 - 10 m): increase in range of communications, delayed response to eclipse
  - *Enhanced propagation suggestive of reduced D-region absorption*
  - *Suggestive of eclipse effects symmetric and instantaneous in E-region, delayed in F-region*

Ham radio links between US and Europe (range ~6000 km)

- Eclipse effects appeared ~19:30 UT, not during the entire eclipse interval
  - ✓ *Earlier opening of 7 MHz band of communications*
  - ✓ *Combined effect of eclipse + sunset (extended shadow like condition)*
  - *Reduced connectivity at 21 MHz, bite-out at even higher frequencies*

Data-Model Comparisons

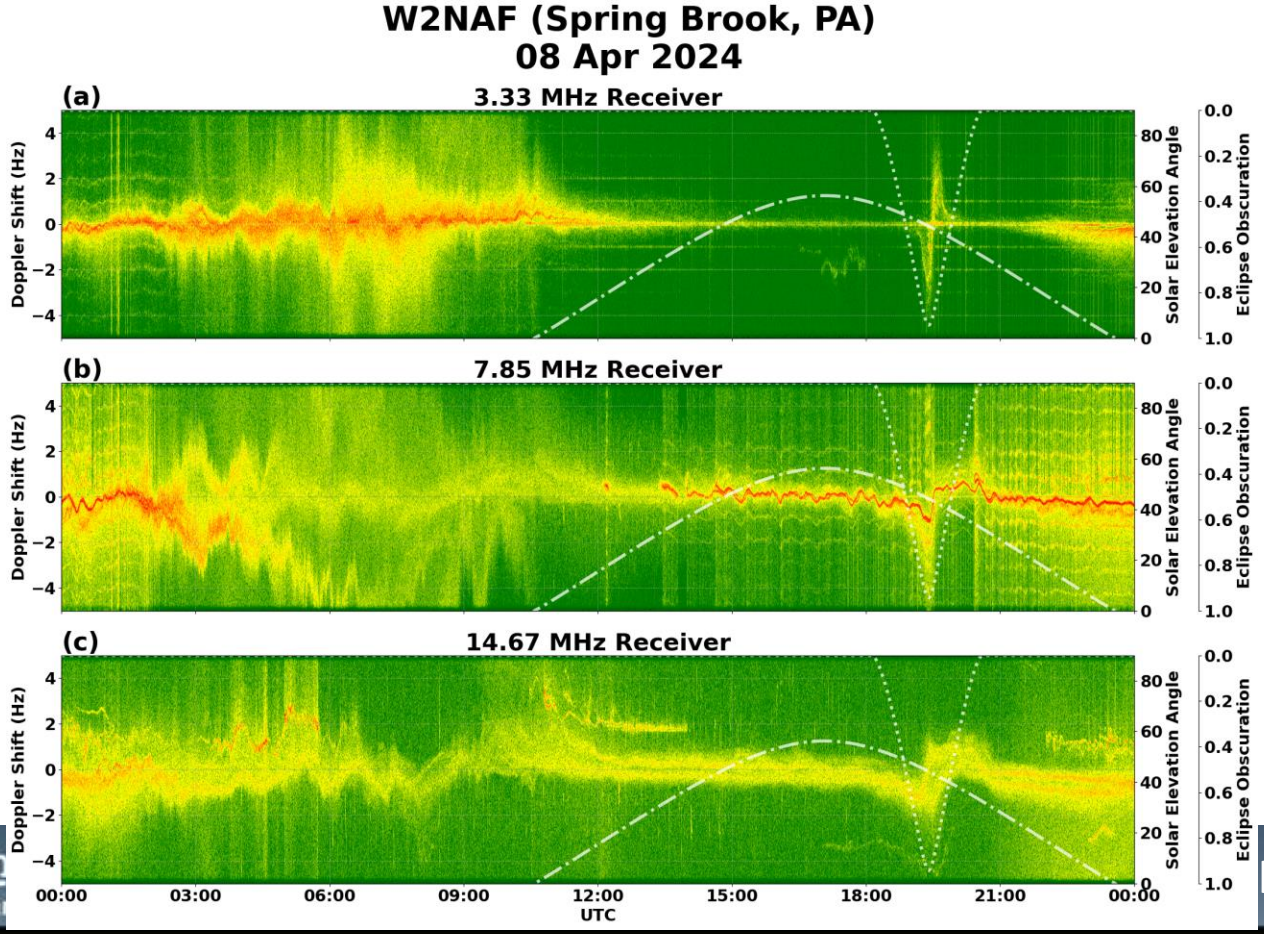
- Ray-trace models with SAMI3 and WaccmX-SAMI3 are in general consistent with the ram-radio observations

HamSCI
http://hamsci.org

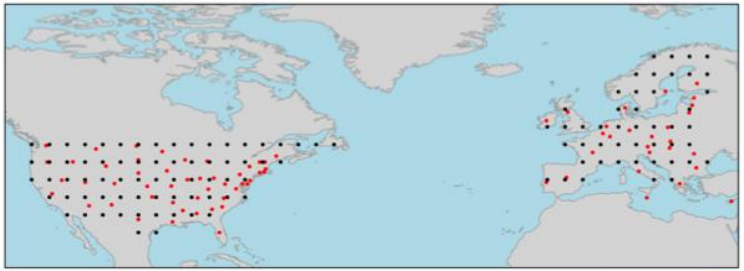
Acknowledgements

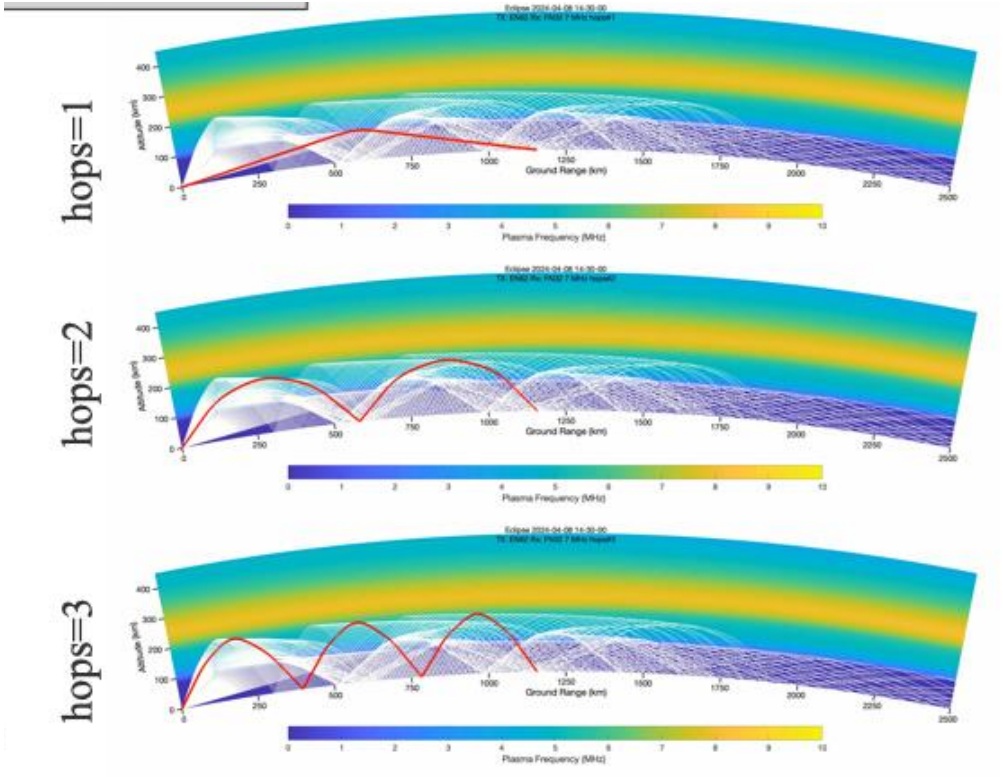
NASA grant 80NSSC23K1322, NSF grants AGS-2045755, AGS-2230345, AGS-2230346, Ham Radio community

CHU → W2NAF 8 April 2024 HF Doppler



Model Raytracing



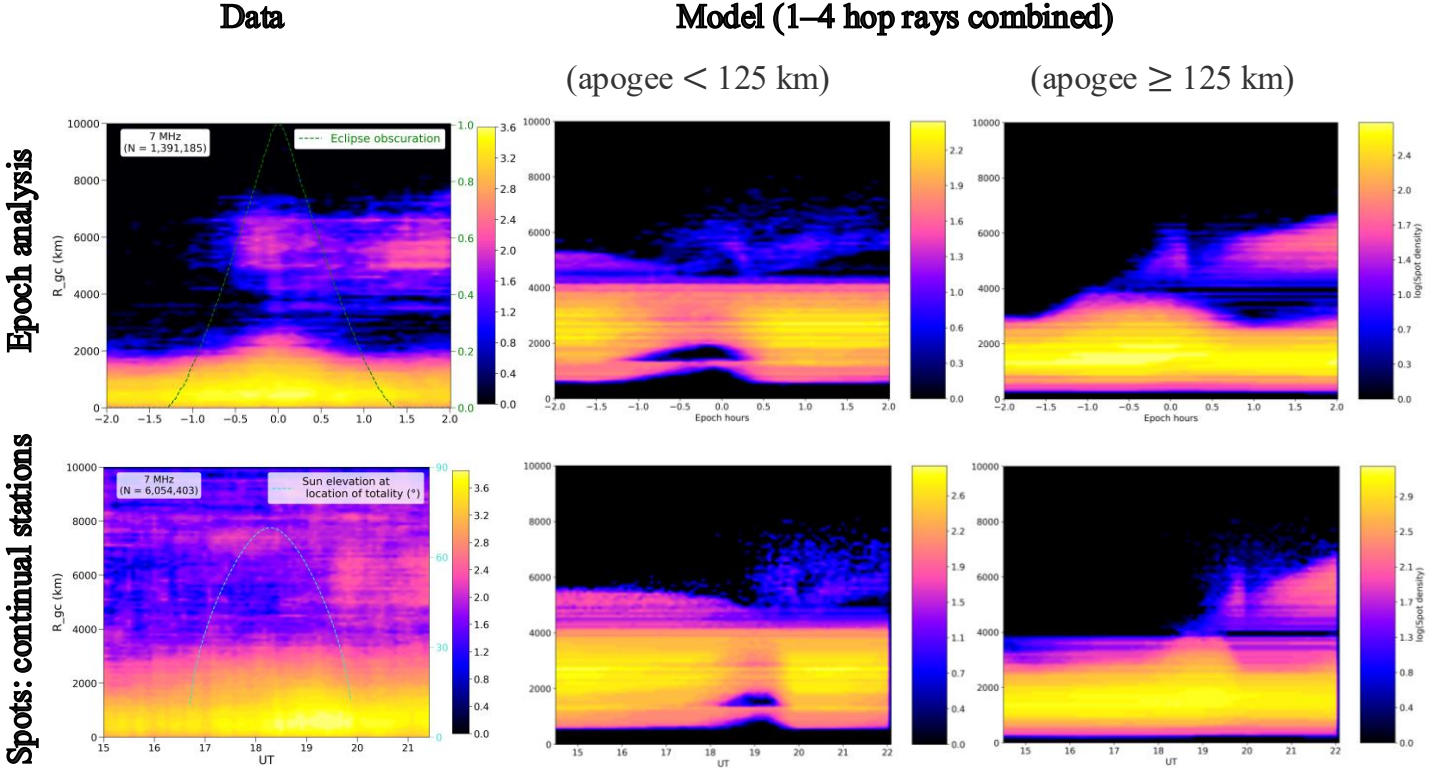


Modeling

- Ionosphere: SAMI3, WaccmX-SAMI3 (*physics based 3D model of ionosphere*)
- Raytrace: PHaRLAP (*Provision of High-frequency Ray tracing LAboratory for Propagation studies*)

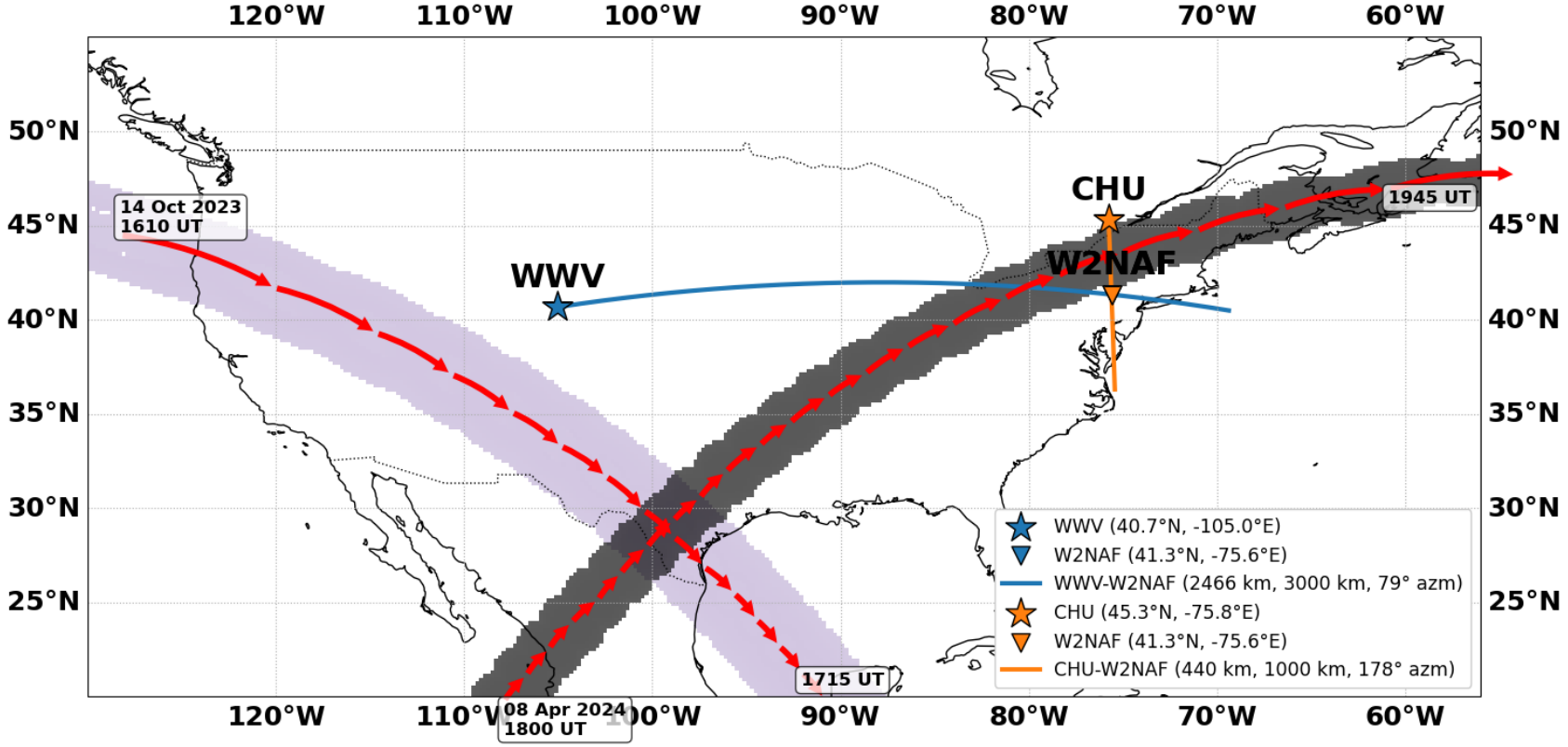
Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology

Comparison: 7 MHz Data & SAMI3



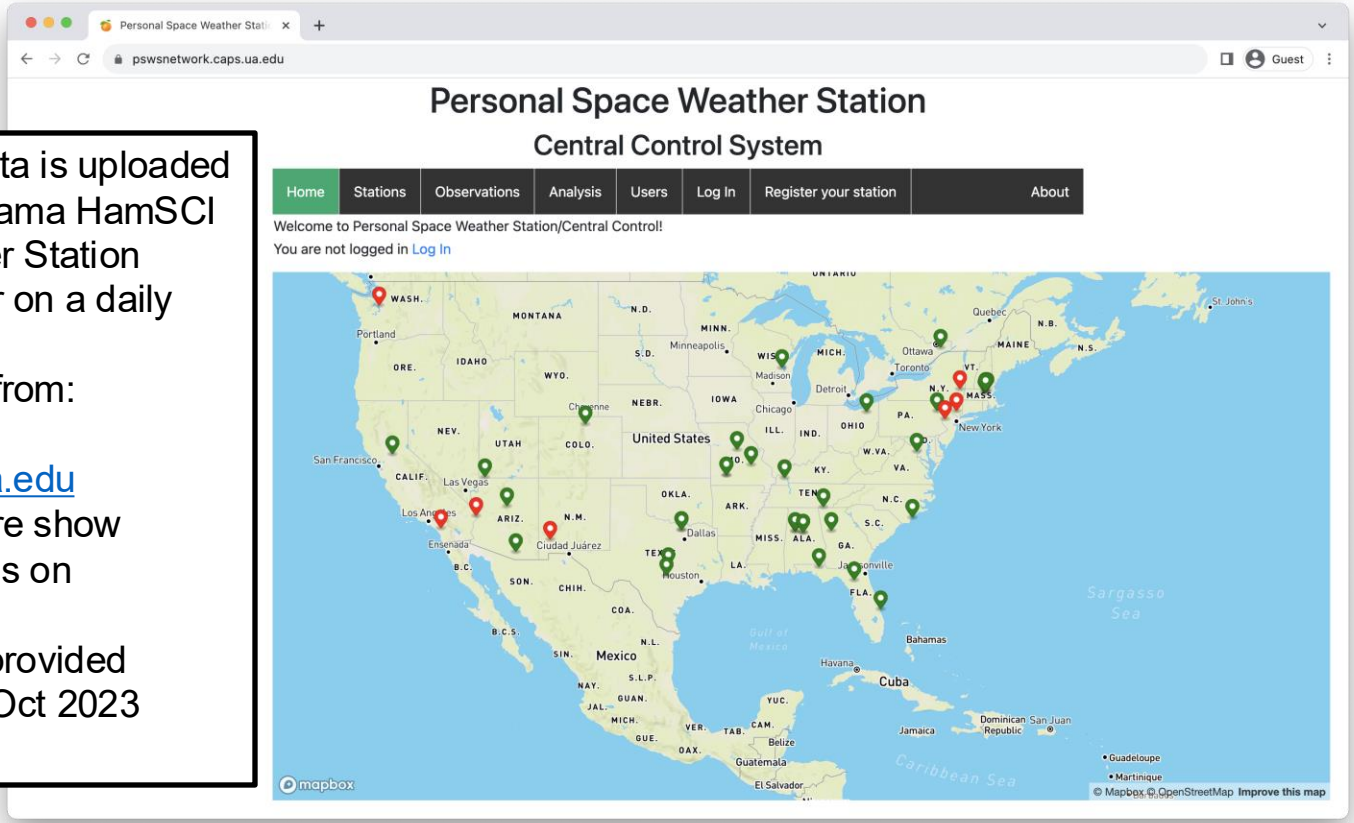
Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology

WWV-CHU-W2NAF



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



What is Meteor Scatter?

- As meteors enter our atmosphere, they leave trails of ionization behind them.
- We can scatter certain radio frequencies off of the ionized meteor trails.
- Today, this type of communication is extremely accessible to hams, thanks to the WSJT software and the MFSK144 mode.

The Geminids meteor shower as seen from the Northern Hemisphere, in December 2013.
By Asim Patel
(https://commons.wikimedia.org/wiki/File:Geminids.jpg)

Meteor Scatter QSO Party Research Objectives

- **Thanks to a recent law change, we can now compare MFSK144 meteor scatter on 10 m (28 MHz) and 6 m (50 MHz).**
- The theory says that the scattering process favors 10m, but there is another process called “initial trail radius effect” which says that ionization trails of certain sizes can cause destructive interference of the signal.
- That trail radius is larger when the meteor ablates at higher altitudes which happens for faster meteors.
- Perseids have a geocentric velocity of 60 km/s and Geminids are 36 km/s which changes their average ablation heights and initial trail radii significantly.
- Relative results from Perseids and Geminids, and other showers as well, should be interesting.

Courtesy of Rob Suggs, NN4NT, NASA MSFC

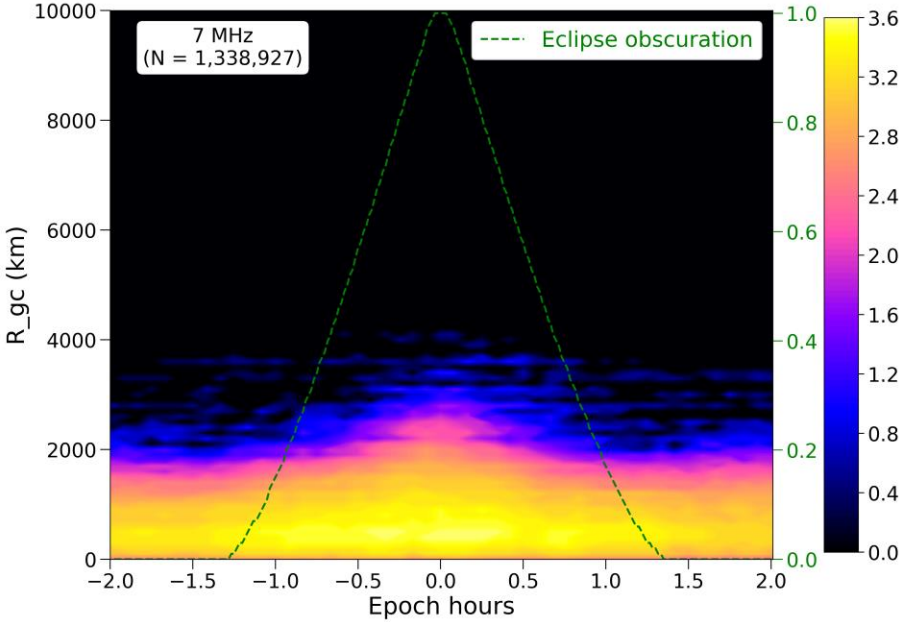
Come join us!

- We are doing some very unique, advanced space physics research right here in Scranton!
- Many of our collaborators are located around the globe.

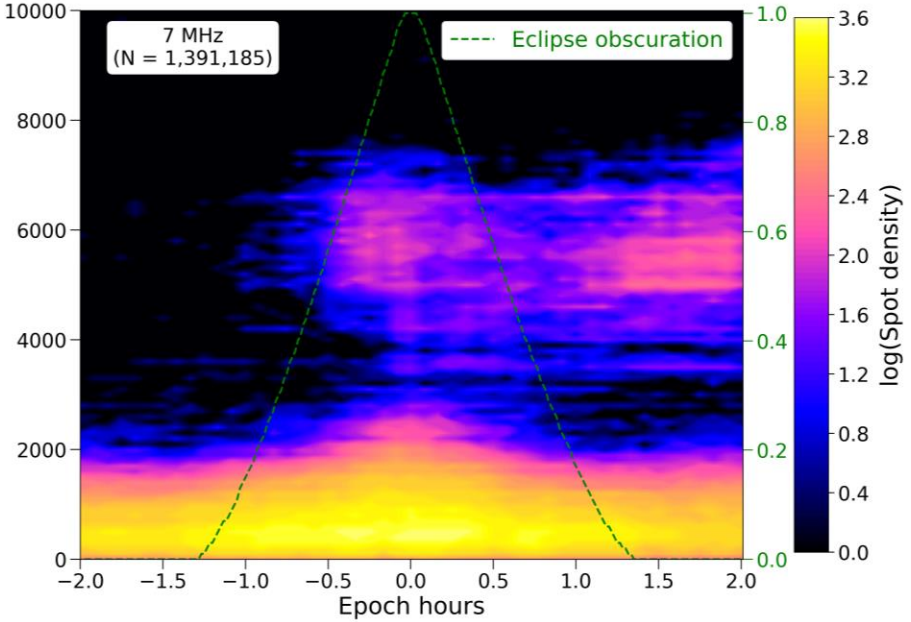
nathaniel.frissell@scranton.edu

SEQP 8 April 2024

7 MHz CONUS Data



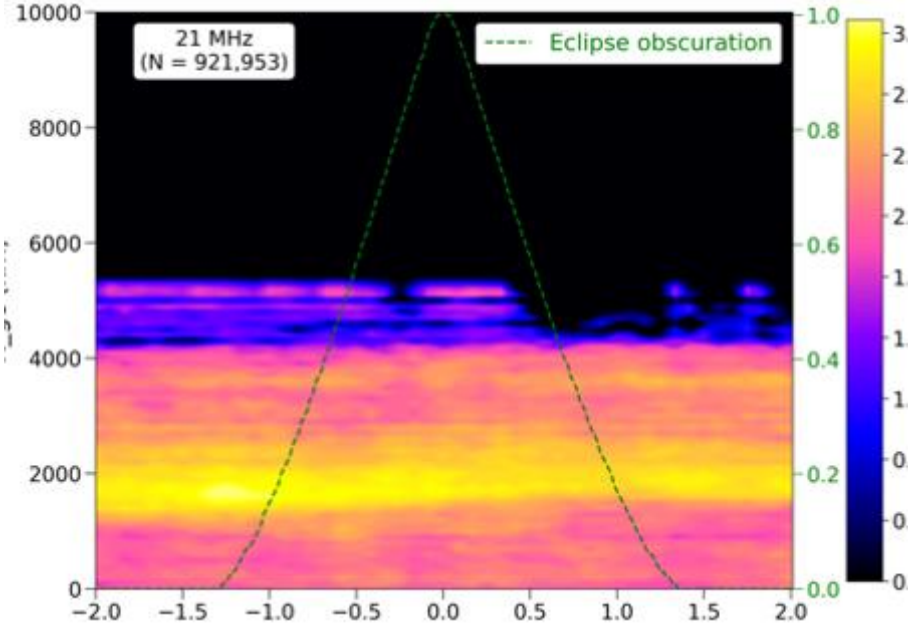
7 MHz Global Data



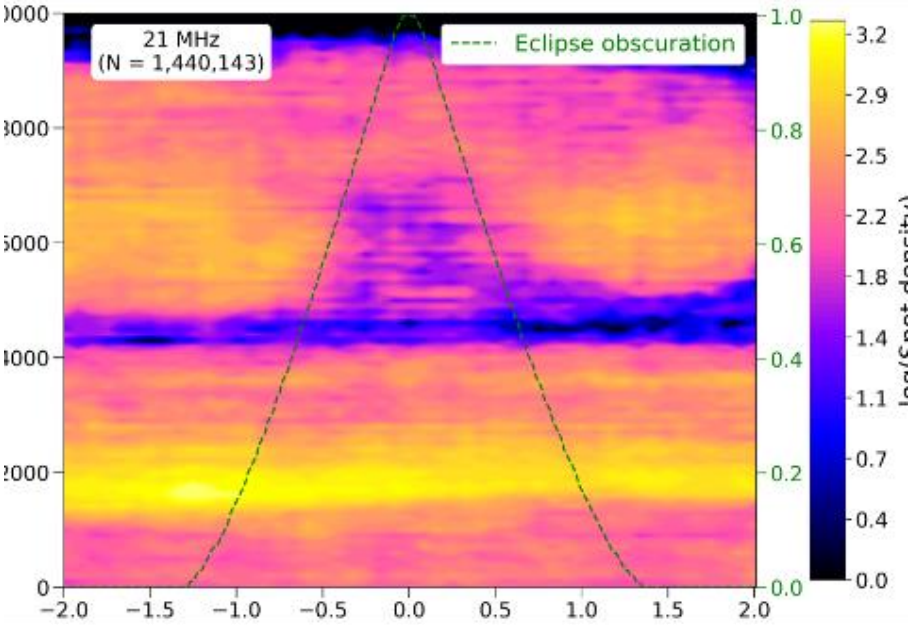
Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology

SEQP 8 April 2024

21 MHz CONUS Data



21 MHz Global Data



Courtesy of Dr. Kuldeep Pandey
kuldeep.pandey@njit.edu
NJIT New Jersey Institute of Technology