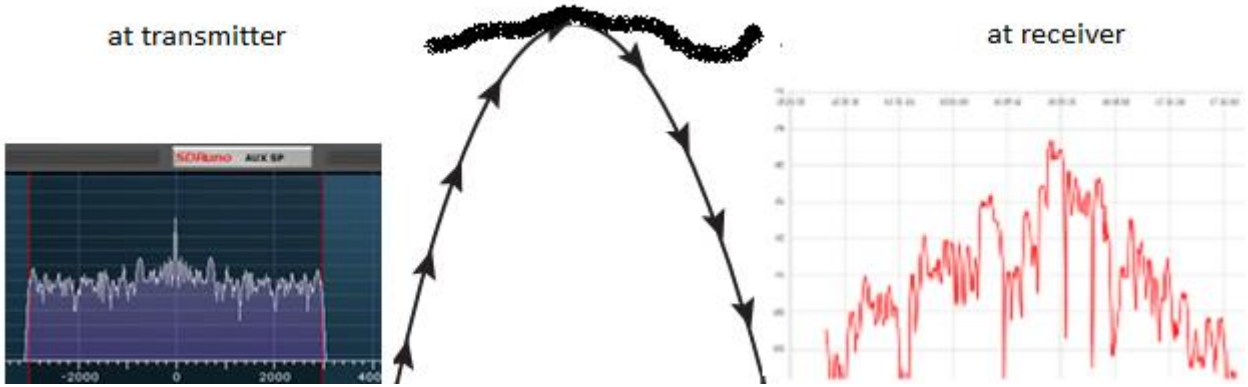
Approaches to identifying Medium Wave signal enhancements in HamSCI's solar eclipse data

Nick Hall-Patch VE7DXR

Background

- **Medium wave (MW) AM broadcasters in the 525-1705kHz band generate continuous carrier waves that can be used as stable beacons to indicate changes in radio propagation over time.**



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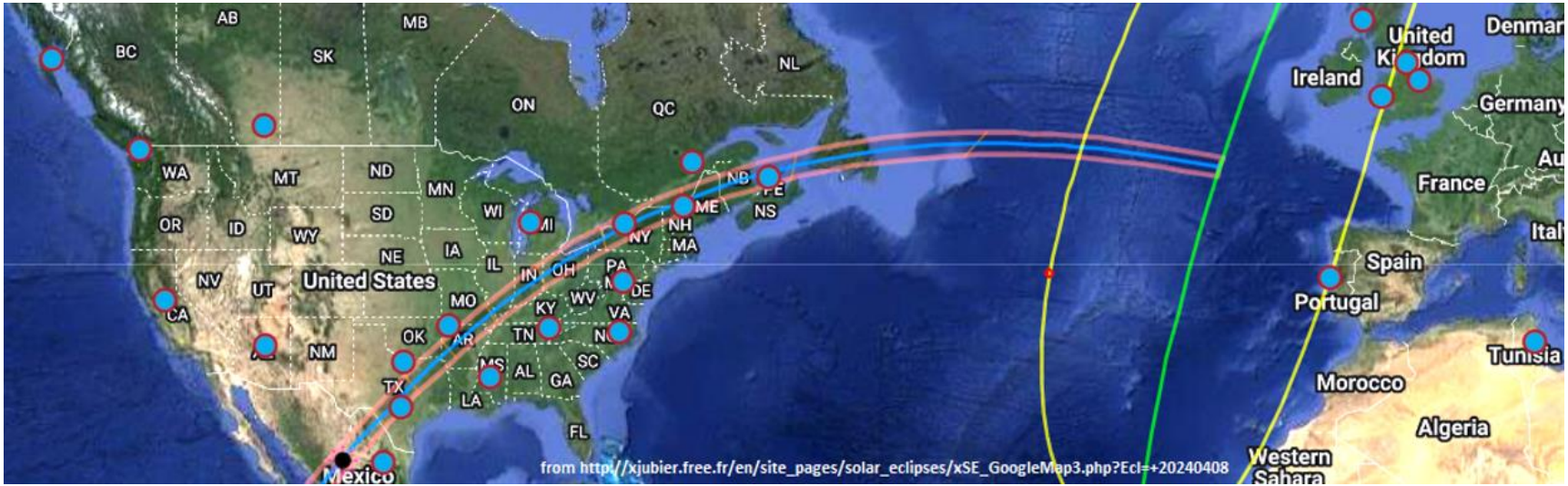
Background

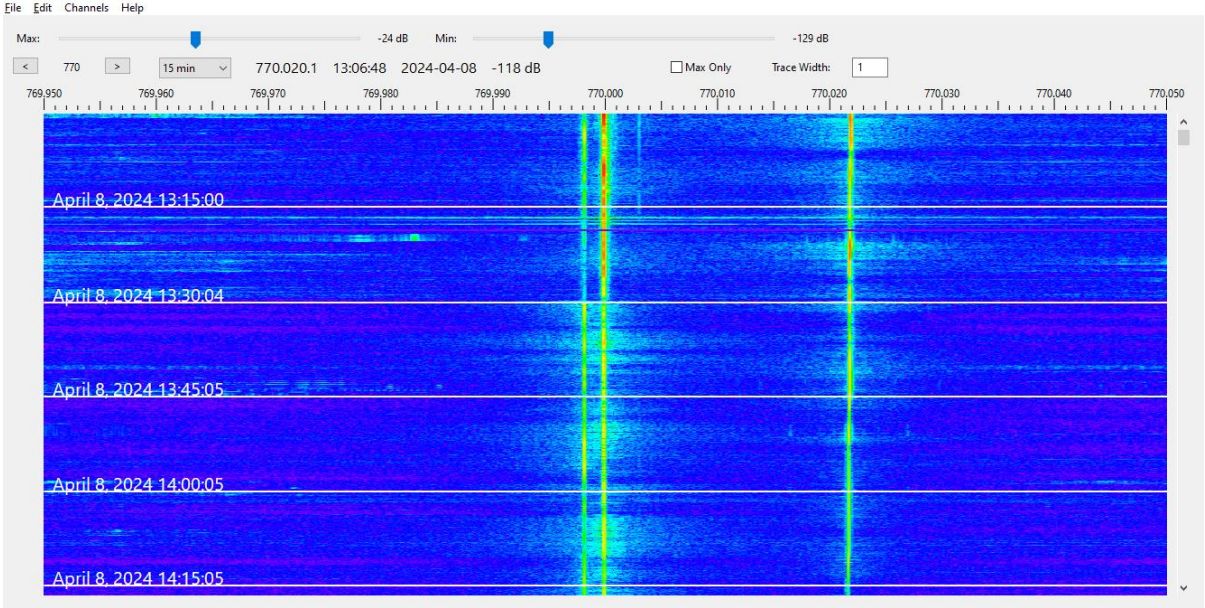
During the solar eclipses of 2023 and 2024, HamSCI organized 27 volunteers in six countries to record the entire medium wave band using software defined radios (SDRs).



Well over 20TB of Medium Wave SDR data was submitted to HamSCI as a result.

Background

- For both eclipses, all data has now been preprocessed using visualization capabilities of Carrier Sleuth software to generate waterfall displays of AM broadcasters' carriers, at 0.1Hz resolution, for each of the 117 domestic broadcast channels.



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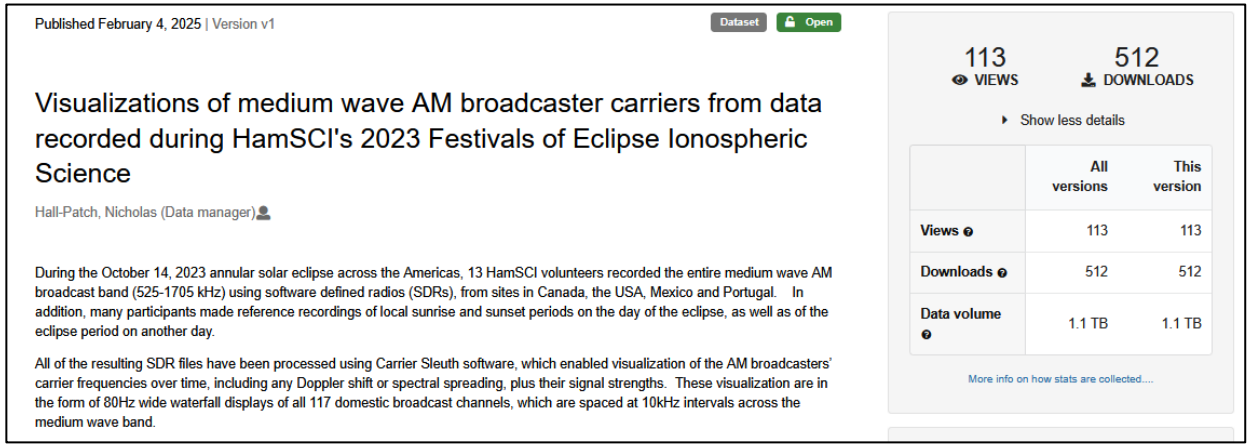
Background

- During the two eclipses' passages, hundreds of enhancements were recorded of AM broadcasters' carriers not normally detected in the daytime.
- All the eclipse enhanced data from 2023 is now publicly available via Zenodo. The 2024 data will follow this year.



Published February 4, 2025 | Version v1

Dataset Open

Visualizations of medium wave AM broadcaster carriers from data recorded during HamSCI's 2023 Festivals of Eclipse Ionospheric Science

Hall-Patch, Nicholas (Data manager)

During the October 14, 2023 annular solar eclipse across the Americas, 13 HamSCI volunteers recorded the entire medium wave AM broadcast band (525-1705 kHz) using software defined radios (SDRs), from sites in Canada, the USA, Mexico and Portugal. In addition, many participants made reference recordings of local sunrise and sunset periods on the day of the eclipse, as well as of the eclipse period on another day.

All of the resulting SDR files have been processed using Carrier Sleuth software, which enabled visualization of the AM broadcasters' carrier frequencies over time, including any Doppler shift or spectral spreading, plus their signal strengths. These visualization are in the form of 80Hz wide waterfall displays of all 117 domestic broadcast channels, which are spaced at 10kHz intervals across the medium wave band.

113 VIEWS

512 DOWNLOADS

Show less details

	All versions	This version
Views	113	113
Downloads	512	512
Data volume	1.1 TB	1.1 TB

More info on how stats are collected....

Introduction

- Unlike the amateur radio eclipse data, which include information about transmitter and receiver, the only initial information available for the MW data is the location of the receivers hosted by the HamSCI volunteers.

- *Where were the transmitters located that were the original source of the data?*

- Our aim is to associate a carrier trace with a particular transmitter of origin. That carrier's variations over time provide a snapshot of the eclipse's effects on propagation.

    - for a DXer it's DX, but for a researcher, it's a transmitter providing a beacon to be used for propagation analysis.

Introduction

- what follows is a MW DXer's approach to extracting clues as to which carrier traces align with which actual broadcast transmitters, and incidentally, to give future researchers an idea of how these carriers had been identified in the first place.

- This is not so much about science, as about the practical details of making sure that the data can be relied upon for scientific purposes.

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Introduction

- Over 20TB was a lot of data, but the Carrier Sleuth preprocessing of SDR files has speeded up finding the signal enhancements that did occur during the eclipse period.

- Stepping through each MW channel in each data set quickly showed which channels would be worth investigating further for the purpose of identifying transmitter locations.

- Note that although Carrier Sleuth has been used in this presentation to display and extract signal strength from the data, other software may well be appropriate for the tasks.

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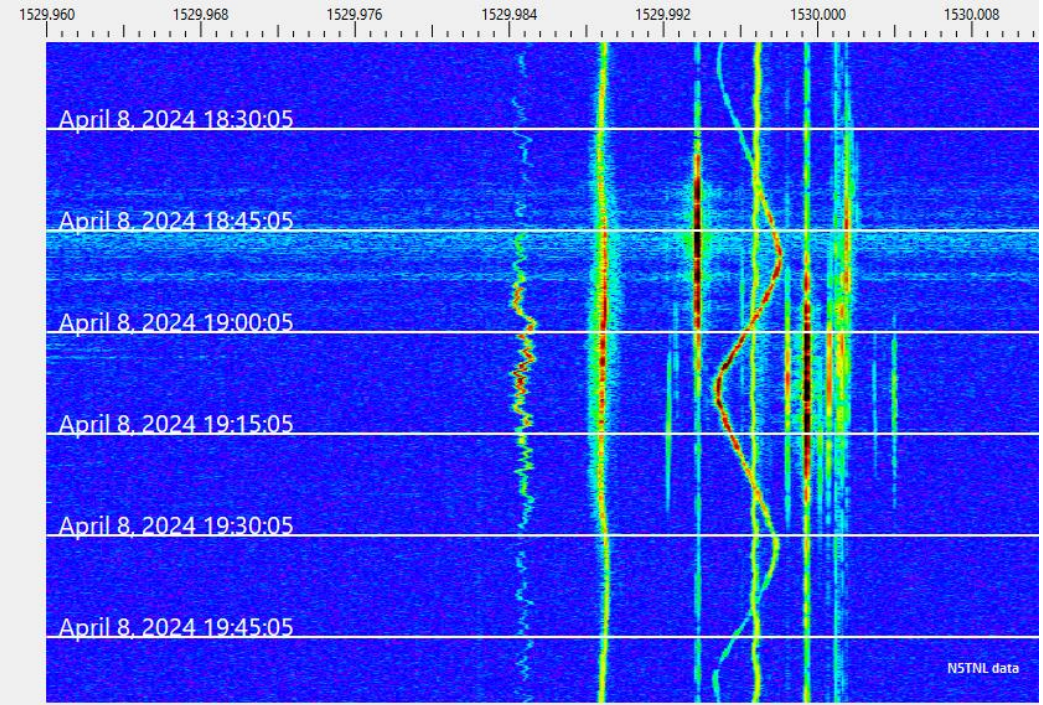
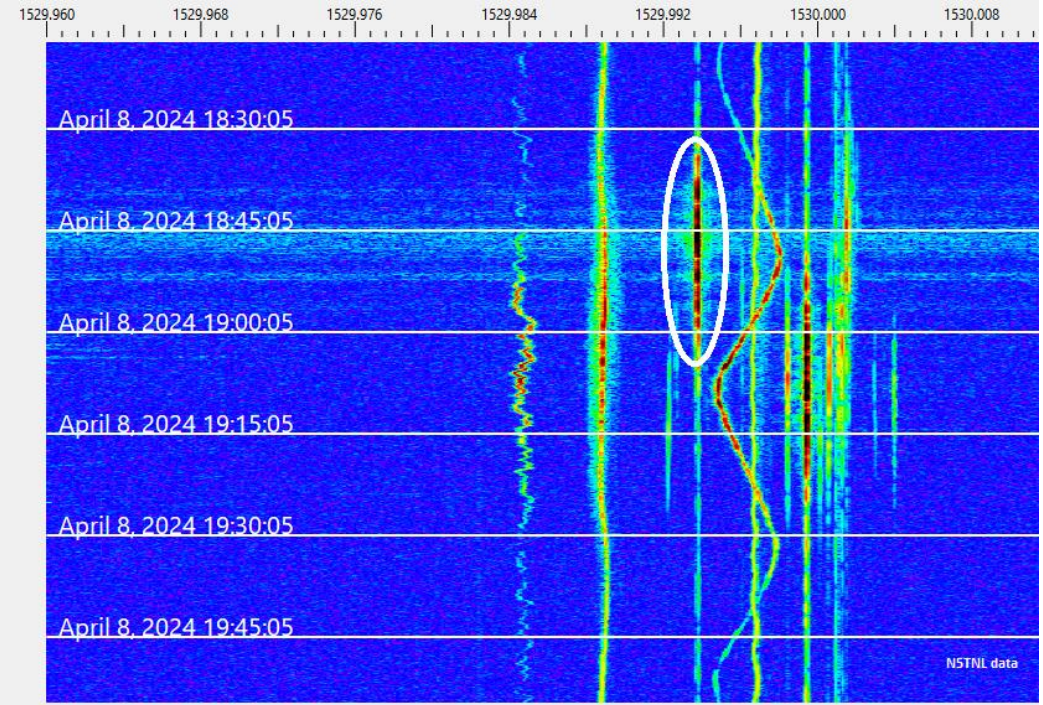
Introduction

- At least initially, these are just lines and squiggles representing signals:



Introduction

But, what broadcast transmitter originated this carrier at N5TNL, Scott Newell's data ?



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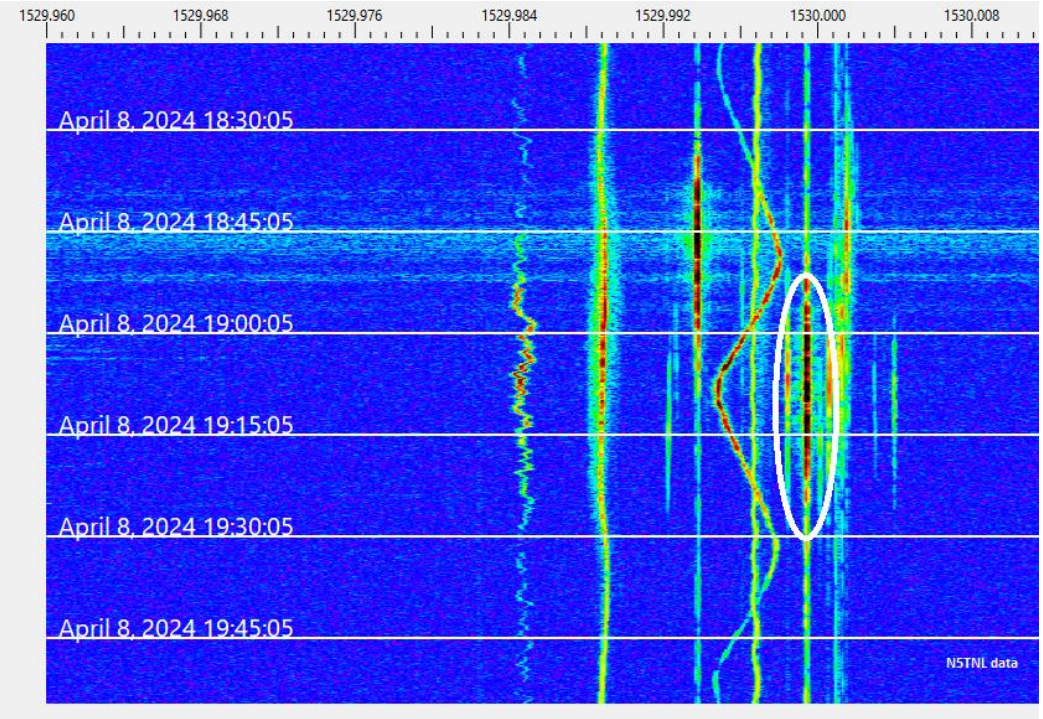
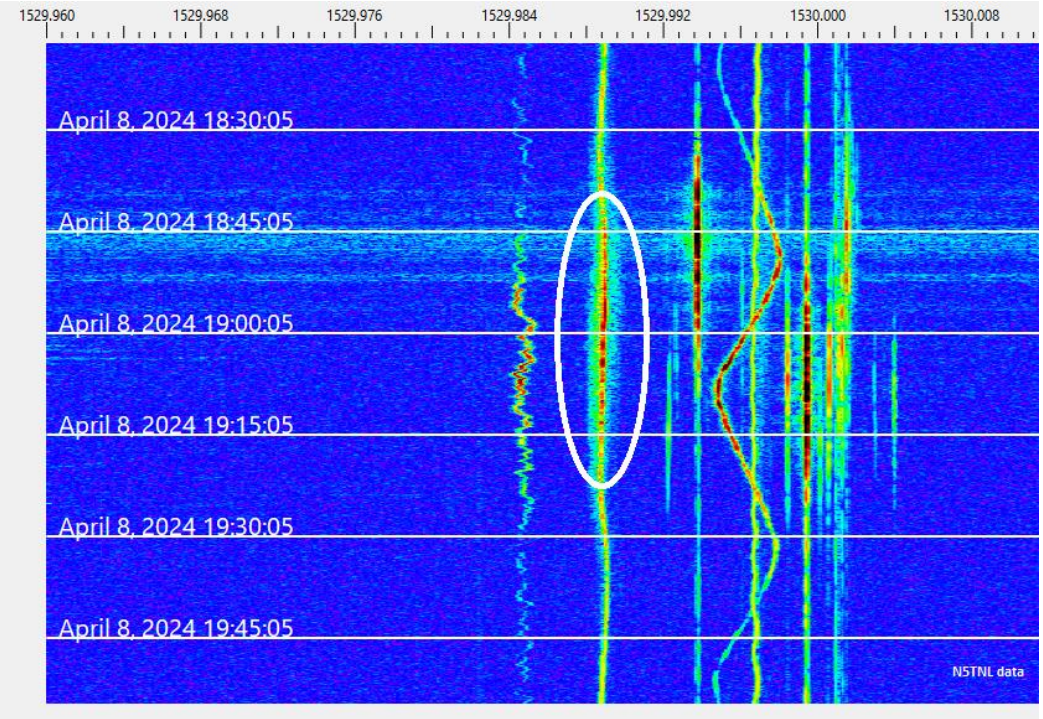
Introduction

or this?



Introduction

or this?



Identifying audio within the data files

- Hearing actual audio during eclipse enhancement provides the best chance for obtaining 100% certainty of the identification of a transmitter site.

- How then to zero in on the channels that delivered audio during the eclipse, rather than just an enhanced carrier on a display?

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Identifying audio within the data files

First approach:

- **Has someone already done the work? That is, has a DXer already gone over the data set, extracted the audio, identified the radio stations heard, and produced a log sheet that has been included with the data set?**

Jim Renfrew, Clarendon NY
APR 8 2024 Total Solar Eclipse (about ¼ mile from the line of maximum totality)
Stations in green are new loggings.
Stations with a box were sent a QSL request

1908	Buzz stops at 1911:25						
1908	690	UNID					WELD?, Eagles
1908	700	UNID					Not Spanish u/WLW; WQVD?
1908	720	WGN					
1908	730	WPIT					
1908	780	WBBM					
1908	820	UNID					Religion u/CHAM
1908	840	WHAS					
1908	880	WRFD					
1913	570	CKGL	ON Kitchener	U-4	10000	10000	City News
1913	640	WWJZ	NJ Mt Holly				Suspect this w/religion
1913	650	WSM	TN Nashville				country mx, "WSM"
1913	690	UNID					CKGM, WNZK, or WELD?
1913	750	WBMD	MD Baltimore				Relevant Radio // 940
1913	760	WVNE	MA Leicester				ACLJ fits sked, no others do
1913	940	WIDG	MI St. Ignace				ACLJ fits sked,
1918	207	GB	NY Buffalo				
1918	215	YTR	ON Trenton				
1918	221	HM	ON Hamilton				

Identifying audio within the data files

- That log file will likely describe the receptions by call letter identification or by a slogan, and the time when it was heard.

- As the log file will be used for scientific purposes, that ID should at least be verified by playing it back using SDR software, and at that point, the identification can be associated with the strongest carrier trace on that channel on the associated Carrier Sleuth display.

- If the recording SDR was locked to a frequency standard, such as a Bodnar GPS Reference Clock, the exact frequency of that carrier provides a “fingerprint” that could be useful information when correlating this recording with other eclipse data sets. It should be noted, as it can help relate a data set with others.
  - Even in the unlocked SDR files, it might be possible to correct the carrier frequency, so noting the precise uncorrected carrier frequency could be useful.

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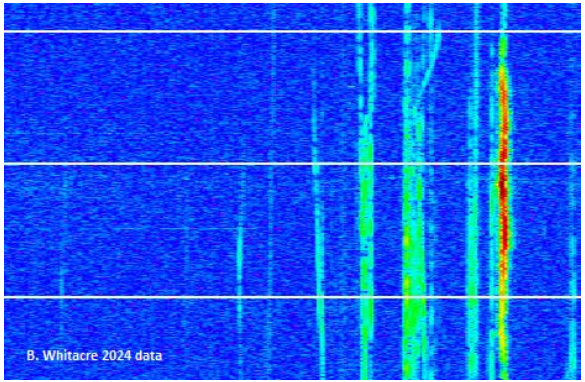
Identifying audio within the data files

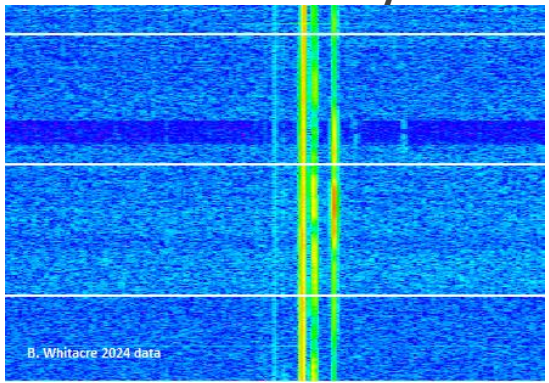
Second approach:

- If there is no list of loggings for a data set, then one could be generated
- This can be done by stepping through the data set's Carrier Sleuth files channel by channel , looking for strongly enhanced carriers during the eclipse period, those more likely to deliver audio. Here are a couple of examples from Bill Whitacre's data:

1630kHz—worth a look

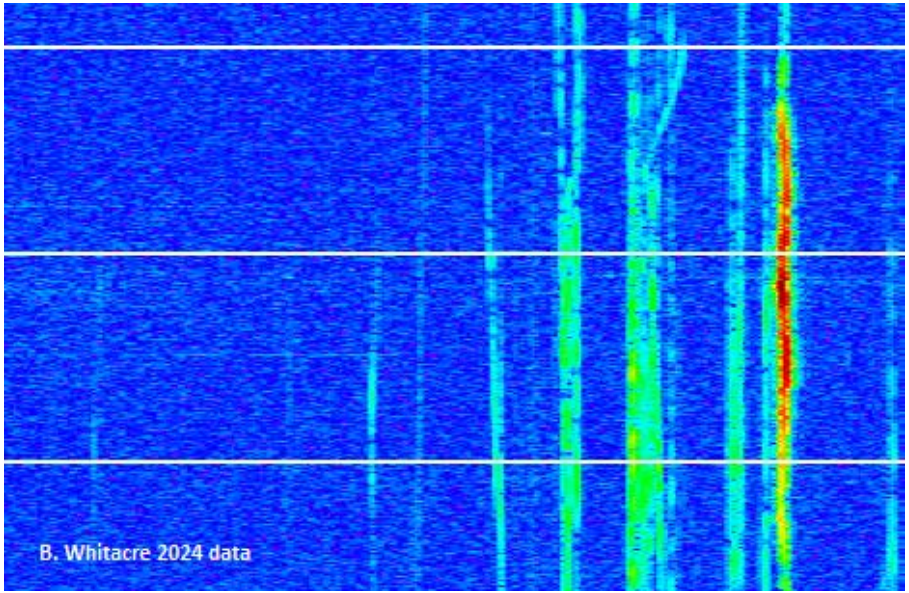


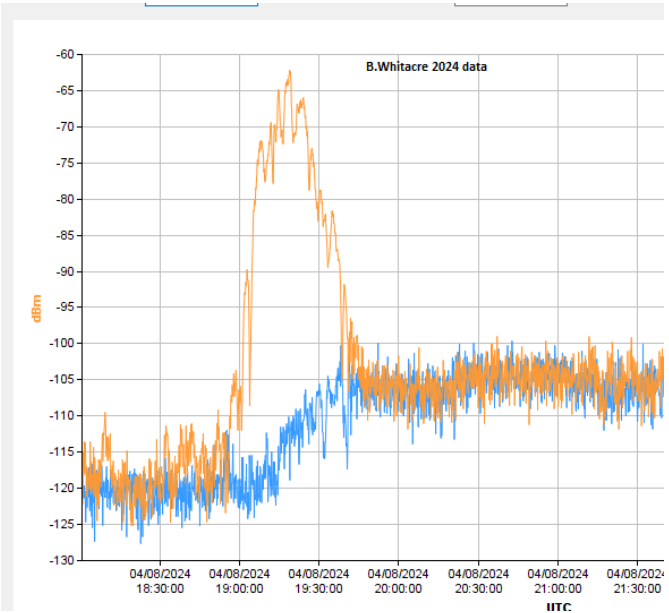
720kHz---unlikely



Identifying audio within the data files

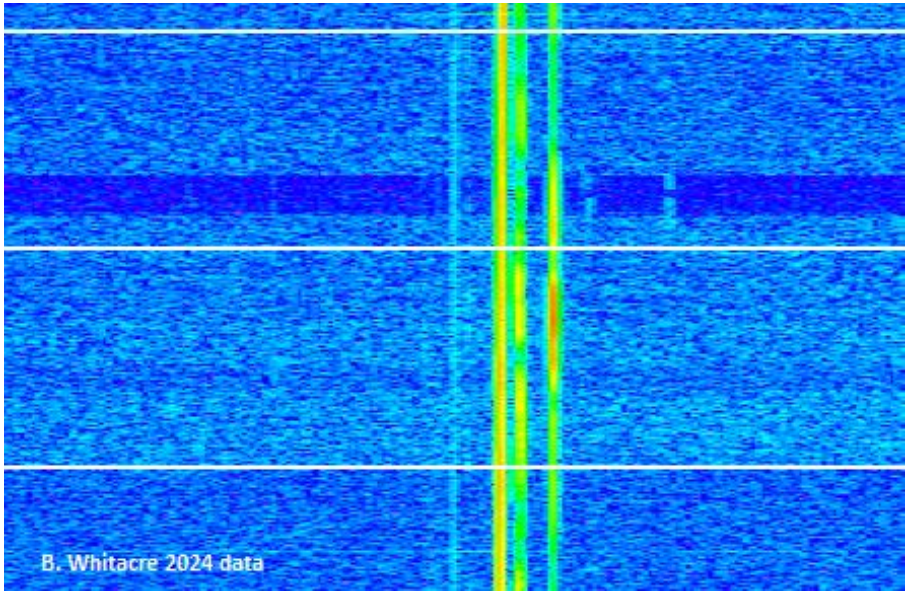
- **Carrier Sleuth can quickly generate a signal and noise display for a channel, and 1630kHz looks promising with at least a 45dB peak :**

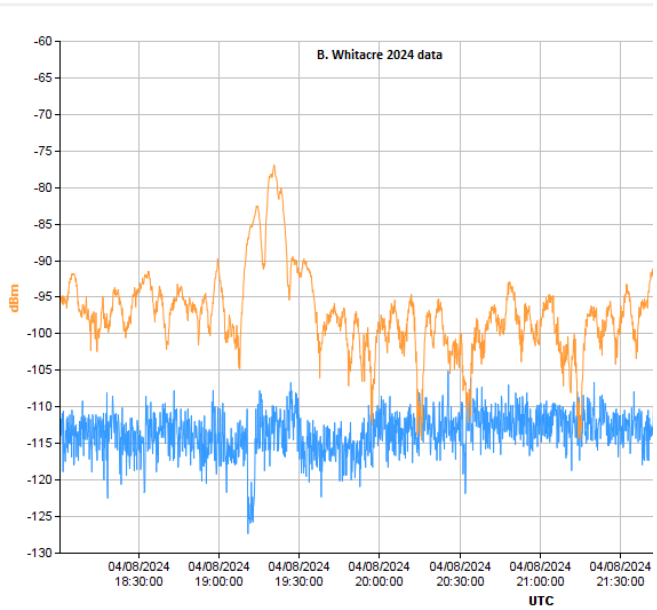




Identifying audio within the data files

- On the other hand, 720kHz included a normal daytime signal, and its carrier was mostly stronger than the eclipse enhanced signal's, with the daytimer's sideband noise only 30dB down from the enhanced carrier:





Identifying audio within the data files

- For an enhanced signal to deliver good audio, its carrier strength should be greater than 40dB over the noise strength.

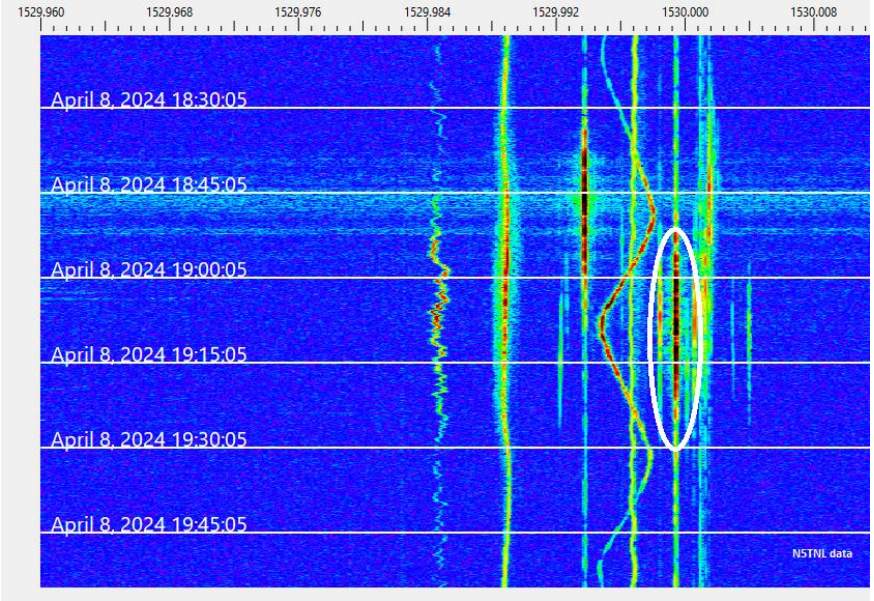
- Preferably, there should be just one strong enhanced carrier per channel, although sometimes eclipse boosted signals overcame normal daytime signals enough to deliver audio themselves.

  --it's more difficult to confidently associate a particular carrier trace with heard audio when there are two or more strong carrier traces at the same time.

Identifying audio within the data files

- If the audio heard includes the top of the hour, listen then. American stations are legally required to identify using call letters at the top of the hour.

- For example, In N5TNL's data set it was easy to identify WCKY, as it identified itself at 1900UT
- It may be worth checking the half hour as well, as some stations do identify then. KE6EE's reception of KKXA-1520 during the 2023 eclipse was identified at 1630UT.



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Identifying audio within the data files

- If the enhanced audio doesn't include the top or bottom of hour, but just programming, then one may be limited to listening through the period of enhancement for a call letter or slogan.

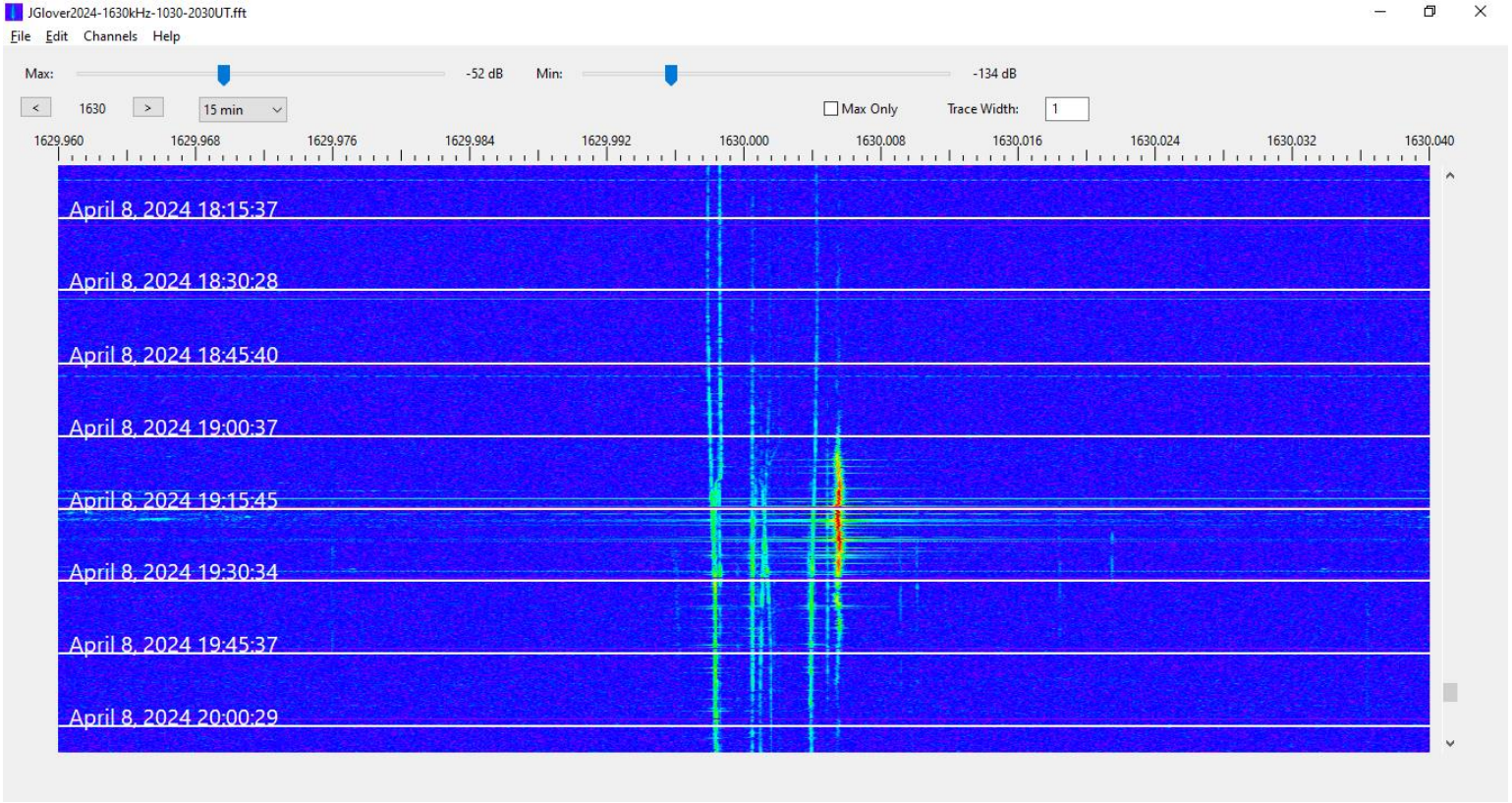
- There is no guarantee of success doing this, as a great deal of AM broadcast programming is syndicated without any insertion of local station IDs

Identifying audio within the data files

Third approach:

- **Note that a number of the data sets included SDR recordings running for 24 hours or more**
- **If there was no station identification on a channel during the eclipse in such a set, it might be possible to track the carrier backwards or forwards to a time where it was full strength over the top of an hour.**
- **For example, the data set from John Glover, W2QL, delivered good audio on 1630kHz during the 2024 eclipse, but without an identification.**

Identifying audio within the data files



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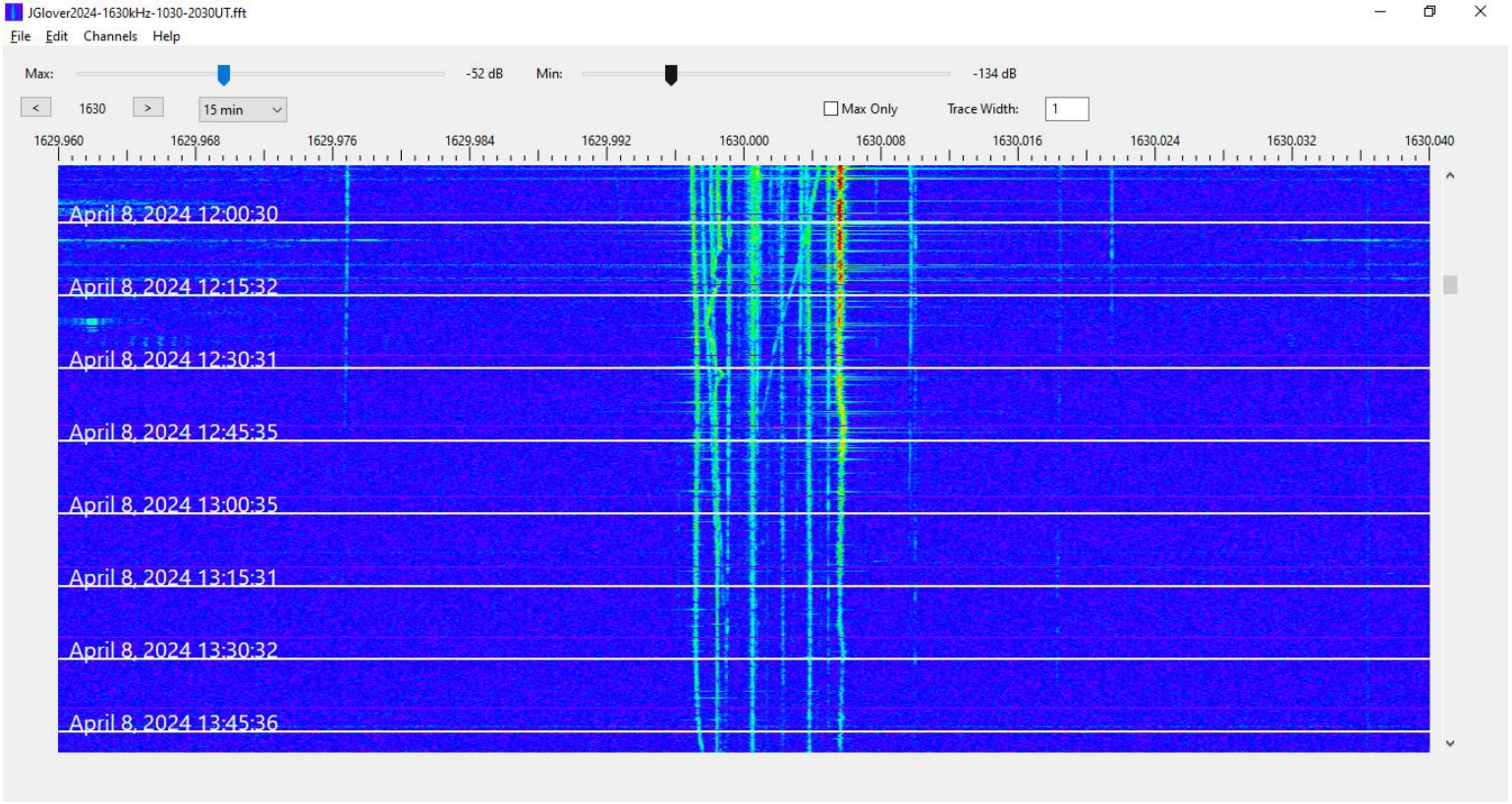
Identifying audio within the data files



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Identifying audio within the data files

- Scrolling back in time to near local sunrise on the day of the eclipse, the exact same carrier was very strong and dominant on the channel at 1200UT, yielding a KCJJ identification from Iowa City, Iowa, ~1300km away.

Identifying audio within the data files

Fourth approach:

- **Find that same broadcaster's audio in another data set at the same time during the eclipse. Perhaps that broadcast would still be audible in the second data set at the top or bottom of the hour.**

- **Using this method, Manuel Caballero, XE2NNS, in Monterrey, Mexico, independently identified several Texas stations by searching through SDR data recorded by Mark Whittington, AG5RT, at Austin, TX.**
- **XE2NNS' data returned the favor, by providing an ID for KGBT-1530kHz heard in N5TNL's data set.**
- **And CBI-1140kHz in Sydney, Nova Scotia was identified at GM7VXR, Paul Crankshaw's site in Scotland by examining data recorded by Brent Taylor, VY2HF, in Prince Edward Island.**

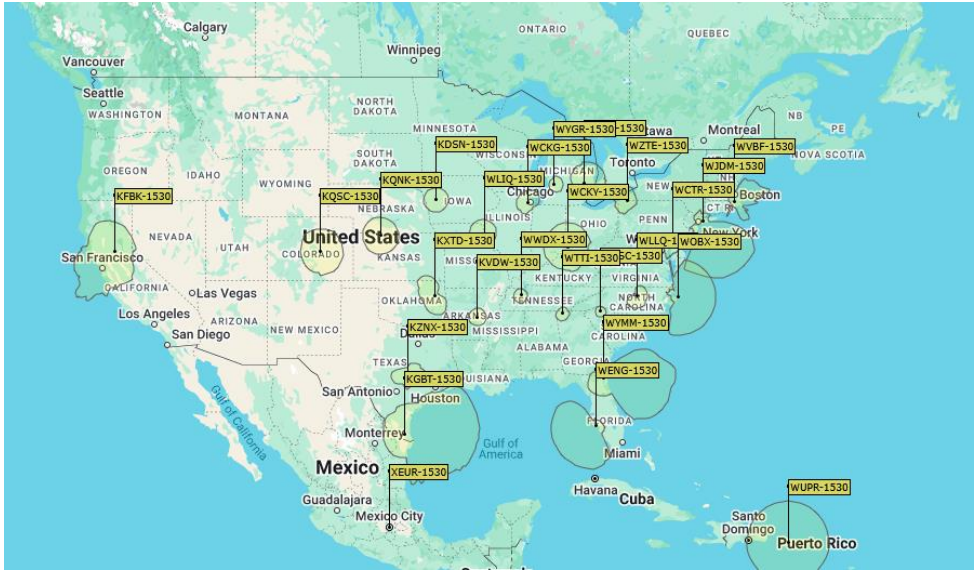
Identifying audio within the data files

- How then to connect slogans and call letter IDs to actual radio stations and from there, to transmitter locations?

- The Zenodo uploads of eclipse data contain a good deal of reference material:
- There are guides to station identifications for Canada, USA and Mexico:
    1. the Canada/US AM Station Info List, specific to the eclipse dates
    2. the IRCA Mexican Log
    3. the IRCA Slogans List
        - This supplements information found in the call letter guides, as many broadcasters identify themselves to their audiences using slogans rather than call signs.

Identifying audio within the data files

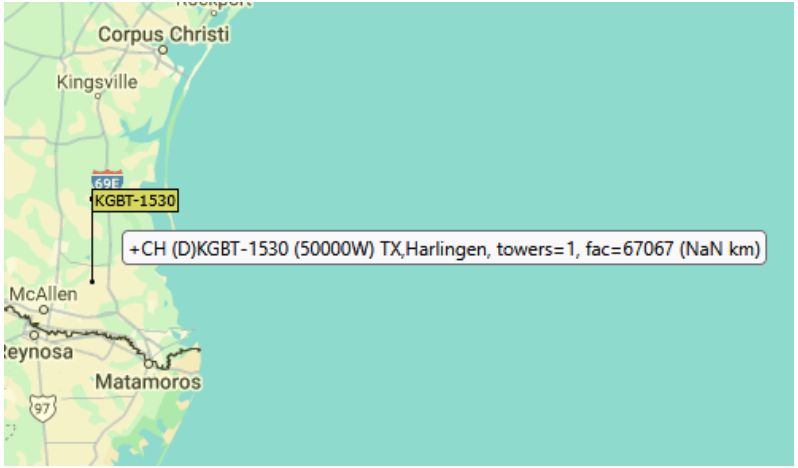
- In addition, there are Radio Data Medium Wave (RDMW) maps of transmitters on each broadcast channel assembled by William Scott, WE7W, from public databases.
- These can give a bird's eye view of possible originating transmitters.



Identifying audio within the data files

- These references provide “City of License” of the transmitters, but the researcher will be interested in a more exact location than that.

- In the RDMW, FCC facility IDs (“fac=”) are included with each transmitter for the USA and Canada



Identifying audio within the data files

- If that facility ID is entered at https://www.fcc.gov/media/radio/am-query , all the transmitter details, including the transmitter co-ordinates, will be provided.

- The FCC doesn't track Mexican facilities as they do Canadian ones, but the IRCA Mexican Log includes transmitter co-ordinates.

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Conclusion

An approach to MW carrier identification using audio heard on a channel has been described.

1. **Are there broadcast station loggings already included with the SDR data files identifying enhanced signals?**
2. **If not, a log list can be created by going through the provided Carrier Sleuth files channel by channel looking for strong enhancements.**
   - **Is there a signal audible at top of hour, when ID's are legally required?**
   - **If not, is there an ID anywhere within the audible programming?**
3. **If not, by tracking the carrier, is there a night-time portion of that data set that might contain a station identification of audio heard during the eclipse?**
4. **If not, can the same programming be heard on someone else's data set which may include an ID as part of their more extensive reception of audio?**

Conclusion

- Using the preceding approaches, it should be possible to build up an accurate database of MW transmitter-receiver pairs that exhibited enhanced signals during the eclipses.

- That is still a fair bit of work, but perhaps MW DXers could assist.
  - Could this be a job for AI? Perhaps those more knowledgeable could weigh in on that possibility?

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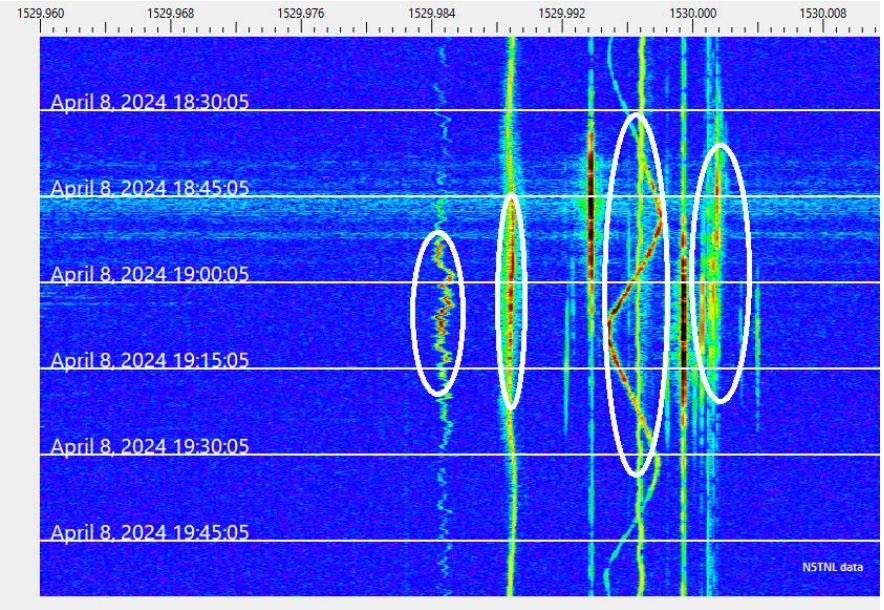
Conclusion

- However, there were far more traces in the Carrier Sleuth files that did not deliver audio. What could they tell us?

- That will be a topic for another day.



Thank you.

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Conclusion

…and special thanks to the participants in the 2023 and 2024 MW Recording Events:

Jim Barnard, W8JB
Burke Baumann, KF7NP
Mike Boice, KW1ND
Andrew Brade, M0XBR
Manuel F. Caballero, XE2NNS
Ashraf Chaabane, 3V9A
John Ciccolella, N3BE
Richard Cook, KE6EE
Paul Crankshaw, GM7VXR
Joe Edge, WA4KYI
John Glover, W2QL
Mike Hayes
Jim McKnight, K2LM
Sylvain Naud
Carlos Nascimento, CT7AUS
Scott Newell, N5TNL
James Niven
Bill Nollman
Nigel Pimblett, VE6TNF
Jim Renfrew
Brent Taylor, VY2HF
George Thomas, W5JDX
Greg Thompson
Tim Tromp, KE8JFM
Jack Weber, M0GKC
Bill Whitacre
Mark Whittington, AG5RT

as well as to Dave Pascoe, KM3T, the Thursday afternoon SEQP / HamSCIENCE crew, and to those who provided no-cost reference material and software for everyone's use