Ham Radio Meteor Scatter Communications

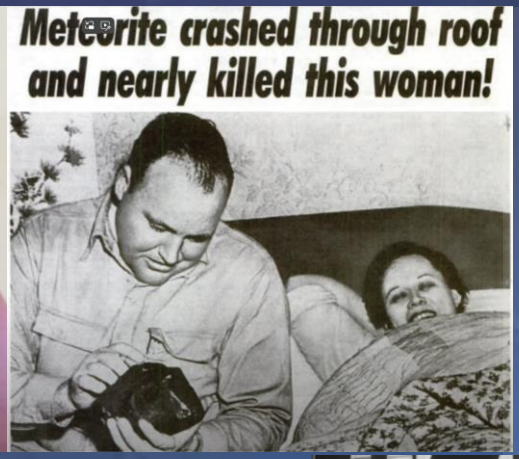
Some factoids presented herein are courtesy Dr. Rob Suggs KB5EZ, “Meteor Scatter Communications: the Science Behind The Pings”, NASA/MSFC/EV44

What Are Meteors?

- Small pieces (grain of sand, particle of dust) of mostly cometary material (90%) or asteroid material (10%). Terminology:
  - Meteoroids = space debris
  - Meteors = meteoroids falling to earth
  - Meteorites = meteors that hit the ground
    - Worth as much as $15k per pound!

- Meteoroid size: between a grain of sand to a meter across *(average weight, 1 milligram)*
- Meteors hit the atmosphere at 25k to 160k mph at a rate of roughly 50,000 per second (2-8 billion per day). Friction with air heats rocks to incandescence about 70 miles up. Most are vaporized. The resulting ion cloud reflects RF energy until it dissipates.
- Meteorites that make it to ground slow to a terminal velocity around 200-400 mph.

Can a Meteorite Hurt Me?



Nov 1954 – Alabaman Ann Hodges was hit by an 8.5-lb meteorite that punched through the roof of her house and hit her thigh - maybe the only verified case of a person being struck.

Oct 1992 – NY resident Michelle Napp had her 1980 Chevy Malibu punctured by a 26-lb meteorite. It was estimated to have hit the car's bumper at 200 mph.

Odds of lightning striking you in your lifetime 1:15,300
Odds of a meteorite striking you in your lifetime are 1:1,600,000
Odds of winning the Power Ball lottery jackpot are 1:292,200,000
*Stop buying lotto tickets and watch out for meteors…

How Long and How Often Are Meteor “Pings”?

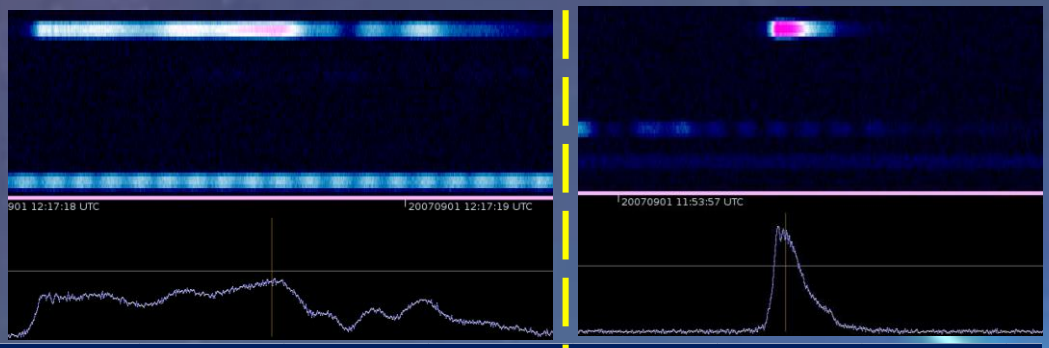
There are two types of meteor trails or echoes:

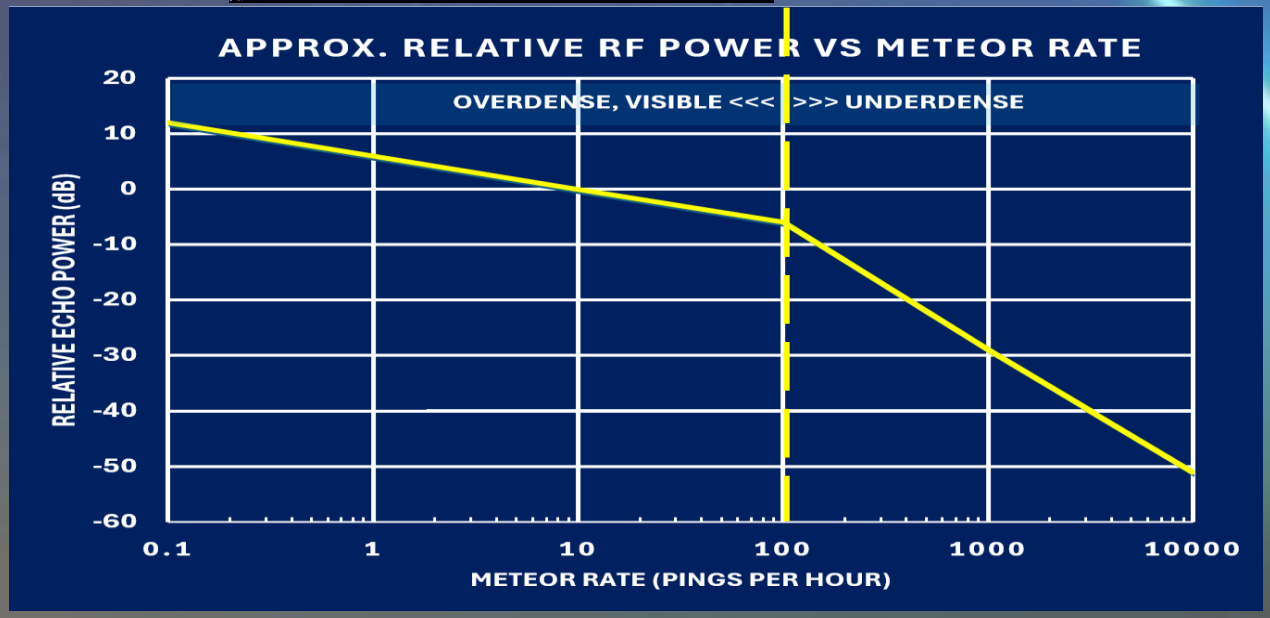
Overdense

Strong, long-lived echoes (>1 second to minutes)

Underdense

Weak, short-lived echoes (<1 second)



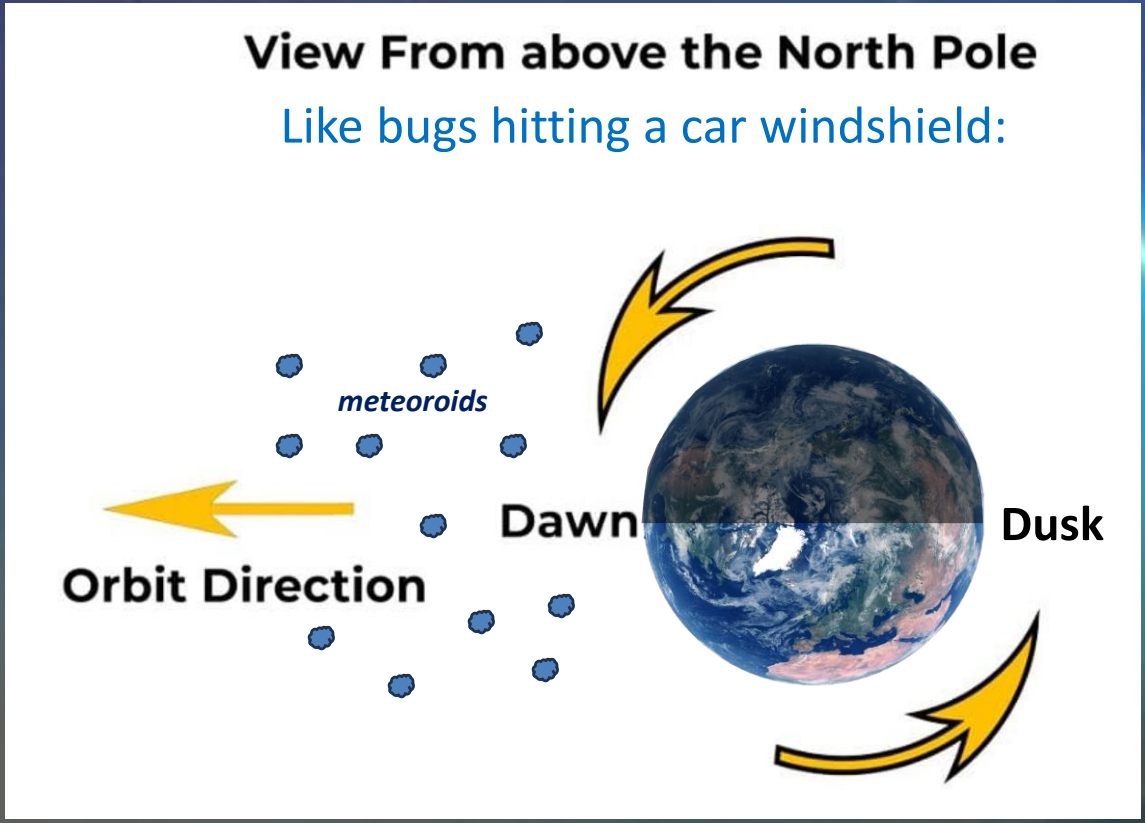


Graphs Courtesy Rob Suggs KB5EZ October 2017

What is the Best Time of Day to Operate?

DIURNAL VARIATION

- Best window: ~6:00 AM local ± 6 hours
  - *The early bird catches the most rocks!*
- Worst window: ~6:00 PM local ± 6 hours
- 4 to 10 times more meteors at sunrise than sunset



What is the Best Time Of Year To Operate?

ANNUAL VARIATION

- There are fewer meteors in the spring, +/-20% annual variation
- Fall and winter are the most active seasons
- Perseids shower peaks next week!
- During showers – there are more and larger meteors

Name	Peak Dates	Approx. Meteors/hour	Avg Speed km/s
Quandrantids	Jan 3	120	43
Arietids	Jun 9 (daytime)	45	41
Eta Aquariids*	May 6	60	66
Perseids	Aug 11-13	90	60
Orionids*	Oct 20-22	20	67
Geminids	Dec 12-13	120	36

*Halley's Comet is responsible for two showers: Eta Aquarids and Orionids

How Far Can I Communicate Off A Meteor Trail?

- The plasma trail left by a meteor starts out denser than the F2-layer in the ionosphere allowing radio reflection up to VHF. At 70 miles up, single hop skip distance is about ~2000 km (1428 miles). This is the DX limit for meteor scatter.
- By comparison, the F2-layer responsible for short wave radio propagation is 250-400 km high. Single hop F2 skip is typically ~3000 km (2100 miles).

Grid Tracker map with 1428 mile range ring)

On extremely rare occasions, a double hop is possible from two meteors in the right place at the right time.

What Ham Band Is Best?

The meteor range equation is derived from the standard radar range equation with terms added to account for plasma density. Take aways:

- Pings are longer and louder at lower frequencies.
  - *2m decodes are 13.8 dB weaker than 6m decodes.*
  - *2m echoes are 12% as long as 6m echoes.*
- Best Band?
  - 10m is a recent MSK144 addition and there just a few experimenters using it. It's also bothered by F2 skip when the band is open. Nevertheless, activity there is expected to increase.
  - 2m requires higher gain antennas and more power.
  - ✔ *6m is the winner: Pings are reasonably long, most HF radios include 6m now (lots of stations), a moderate size antenna with some gain and barefoot 75W should work well.*

Modes Used For Meteor Scatter

- **SSB/CW**
  - Before Joe Taylor, meteor scatter was done using SSB voice with 30-sec TX/RX periods. The exchange was a signal report (ie, “5 by 9”) and “Roger”. There were no grid zones back then. A clock with a second hand set to WWV was used for skeds, arranged on a SSB net at 3815 kHz.
  - Some work was also done using high speed machine CW.
  - The N7RF logbook from 1979-80 shows four successful SSB QSOs on 2m (TX, WA, CA) and seven on 6m (SD, MN, ND, MT, SD, WA) representing many hours of calling CQ.

- **EARLIER JOE TAYLOR DIGITAL MODES:**
  - **FSK441 – (**2001) was designed for meteor scatter operation
    - 4 tones (4-FSK), 441 baud (147 cps), self-synchronizing
  - **JTMS** - Also designed for meteor scatter
    - Uses minimum shift keying (MSK) at 1378.125 baud (197 cps)
  - **JT6M** - Optimized for meteor scatter and ionospheric scatter on 6 meter
    - 44-FSK at 21.53 or 43.07 baud (16.15 or 32.3 cps)

- **WSJT-X MSK-144**
  - **(**2017) Minimum Shift Keying (MSK) modulation used for amateur meteor scatter. Transmits 144-bit packets at 2000 baud.
  - The FCC allows (as of January 2024) use of MSK-144 and Q65A modes on 10m and below because they do not exceed 2800 Hz of bandwidth.

Station Setup

("MSK144 is not a QRP activity")

	10 meters	6 meters	2 meters
Computer:	Anything that will run WSJT-X (including Raspberry Pi) with sound card interface to radio.		
Radio:	Modern 100W HF xcvr	Modern 100W HF+6m xcvr	All mode 2m xcvr: FT991A, FTX-1, IC-9700, etc.
RF Power:	Barefoot: 50W-75W	Barefoot: 50W-75W >100W: most HF HPAs	LDMOS HPA: >200W RM Italy LA-250 Toptek PA-150 /PA-350
Suggested Antennas*	Dipole, EFHW, Moxon, small Yagi, spider beam, etc.	2el Moxon, 3+ element Yagi	9+ element Yagi
Feedline Loss	Try to keep coax loss under 2dB. More important at 2m than 10m.		

* Meteor scatter favors horizontal polarization. A vertical does not work well.

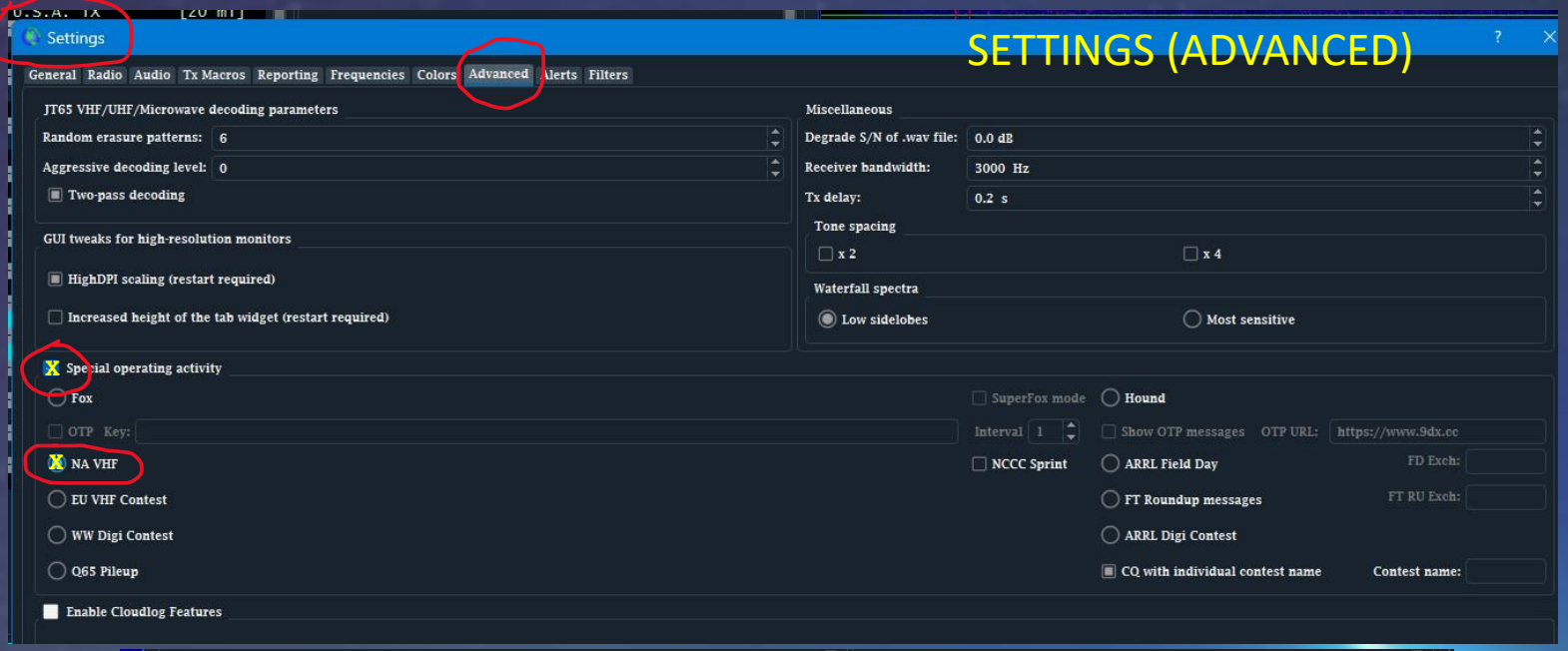
N7RF Station

	10 meters	6 meters	2 meters
PC:	ASUS ROG STRIX Laptop (64-bit Win-11)		
Radio:	FTDX101D	FTDX101D	FT-991A
RF Power:	75W barefoot	75W barefoot or ACOM-1200S (operate@200W)	Eb104.ru 1kW LDMOS HPA (operate@330W)
Antennas:	40m or 80m EFHW	5el Cushcraft Yagi	12el M^2 Yagi
Feedline Loss:	~1.1 dB Includes SP8T	~1.5 dB Includes SP8T	~1.5 dB (mostly LMR600)

WSJT-X Software Setup

- Most of you use WSJT-X on FT8. Therefore I am not going to cover a basic WSJT-X setup. I assume you know this already…
- That being said,
  - There is a comprehensive tutorial is available here: https://k5nd.net/2023/04/meteor-scatter-propagation-how-it-works-getting-on-the-air/
- Jim K5ND does an expert job explaining how it's done using the WSJT-X version 2.8.0 Improved version.
- I will cover this much: Since two-meters is more challenging than six, most rock chasers use the "NA VHF Contest" mode to fast-track QSO's on that band (next slide):

WSJT-X Software Setup, Two Meters Only

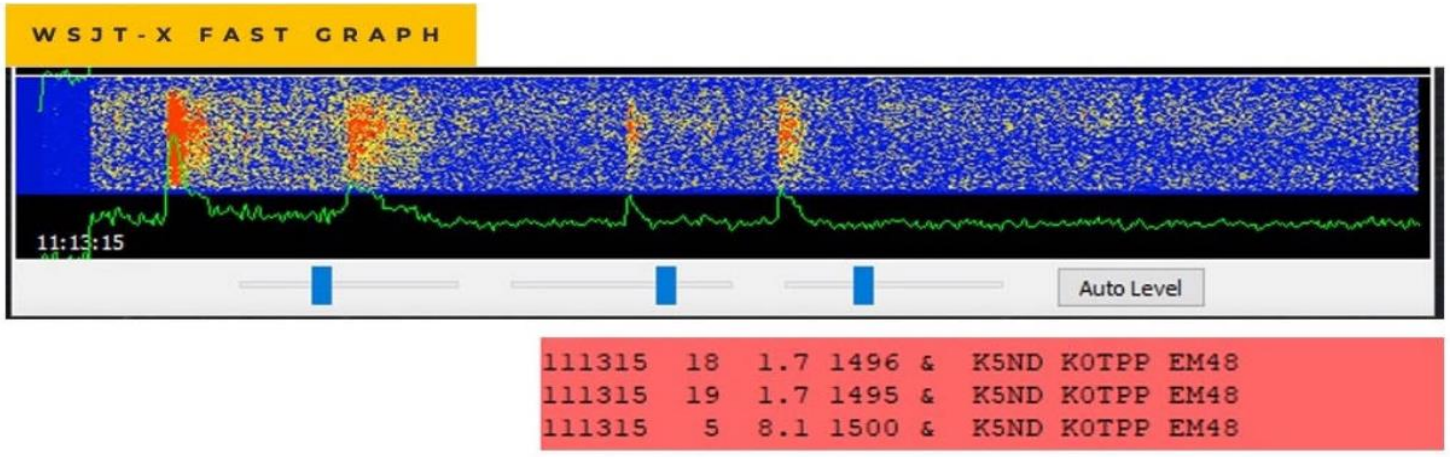


Where Did the Waterfall GO?

When you select MSK mode, the normal waterfall display disappears and is replaced by the Fast Graph display. Think of it as a sideways waterfall, 3000 Hz tall and 15-seconds wide. The green line at the bottom is total instantaneous signal power. Unlike FT8, bursts are decoded instantly instead of at the end of a period.

From K5ND:

The nearby screenshot shows the WSJT-X Fast Graph display when the mode is set to MSK144. You can see meteor "pings" at 1.7, 3.5, 6.1, and 8.1 along the full 15-second window. The brighter the ping appears, the stronger the signal. For example, the pings at 1.7 seconds are +18 and +19 dB, while the one at 8.1 seconds is +5 dB. These are the only pings that have been decoded, which are displayed in the red box.

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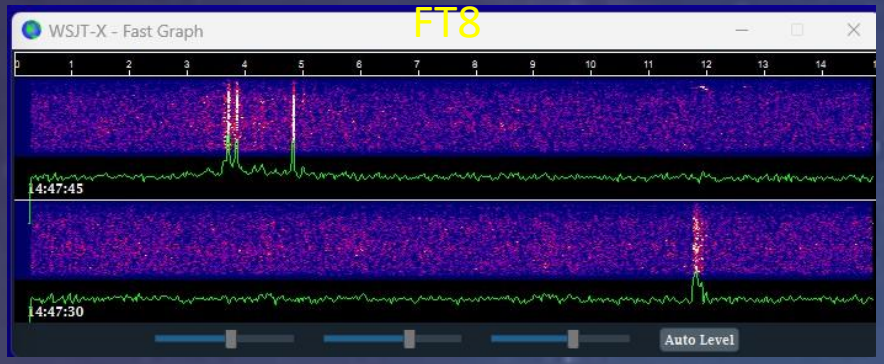
111315   18   1.7 1496 &   K5ND K0TPP EM48
111315   19   1.7 1495 &   K5ND K0TPP EM48
111315    5   8.1 1500 &   K5ND K0TPP EM48
```

Making Contacts

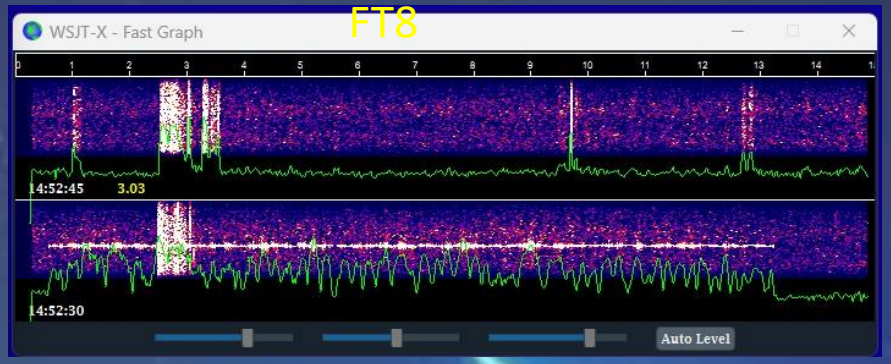
- Calling frequencies are: 28.145 MHz, 50.260 MHz and 144.150 MHz
- Check PSKreporter to see what's going on. Point your antenna in the general direction of activity. Looking east, transmit on *even/1st* time slot. Looking west, use *odd/2nd time slot*.
- Be patient.
  - Minutes can pass without seeing a single ping.
  - Not all pings get decoded.
- Check the chatter on the Pingjockey website: https://www.pingjockey.net/cgi-bin/pingtalk
- Blind calling is OK, but during meteor showers, it gets busy.
  - Be mindful of "local" QRM (ground wave from here to Austin…)
  - Announce CQ activity in advance on Pingjockey. For example:
    - "CQ 50.260 1ST LOOKING NE"
    - If 50.260 is busy, QSY 5kHz: "CQ 50.265 1st LOOKING NE"
    - On 2m, "CQ 144.150 1st cmsh NE" *cmsh* says you are using NA VHF contest mode, short form.

Using FT8 Signals to See Meteor Activity

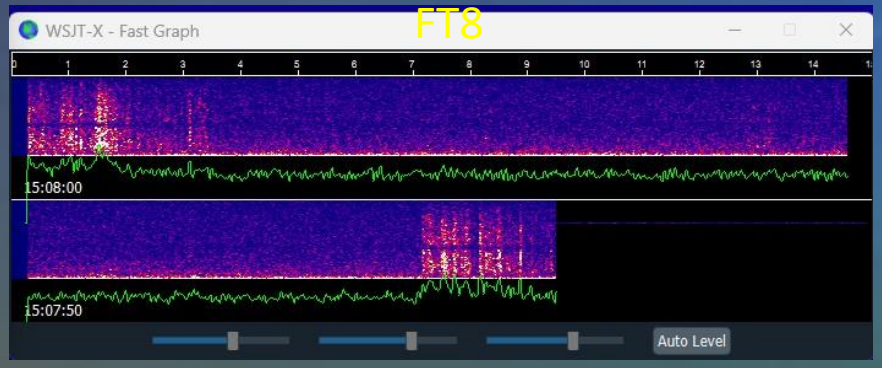
10M: Fast Graph tuned to 28.074 FT8



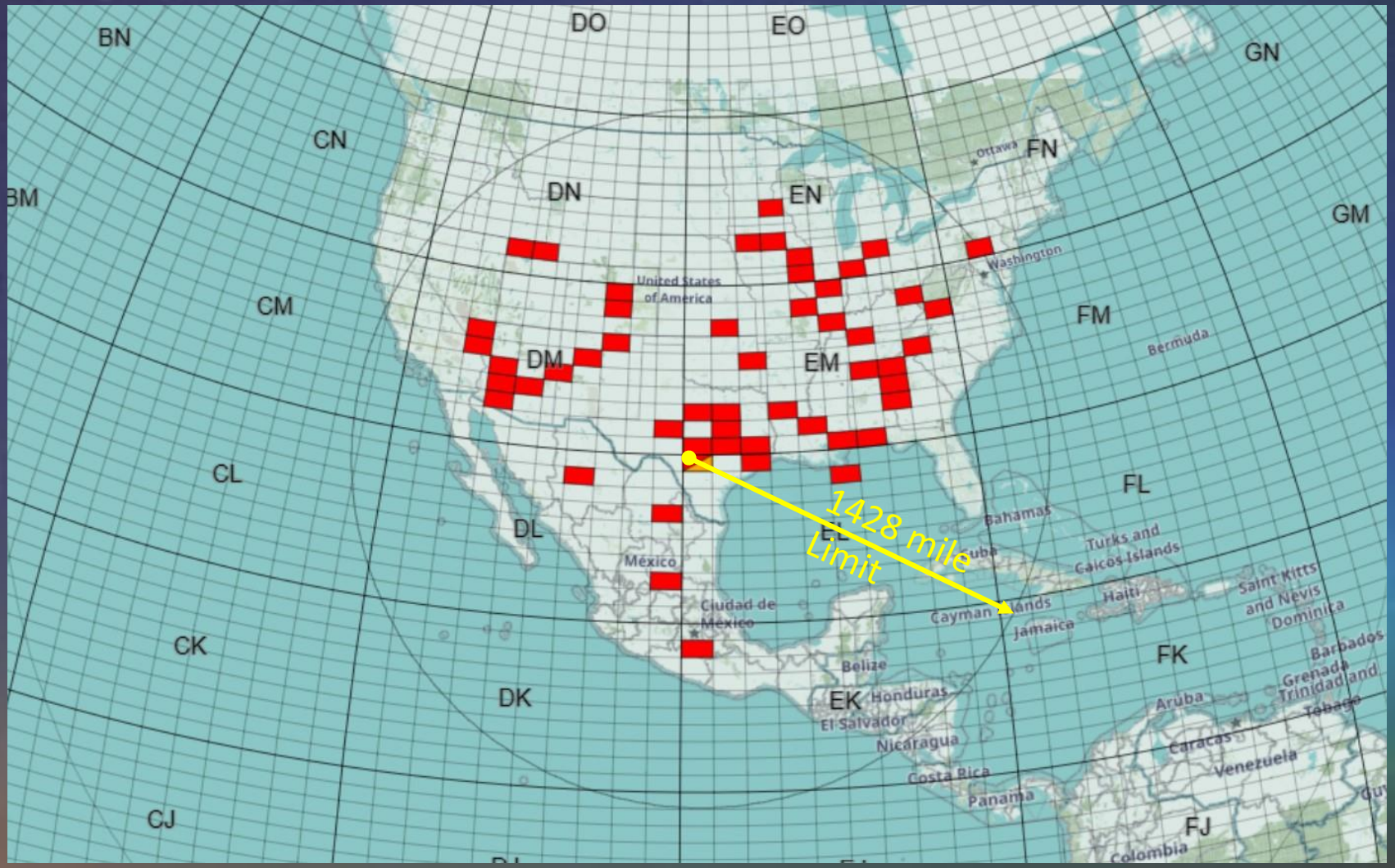
6M: Fast Graph tuned to 50.313 FT8



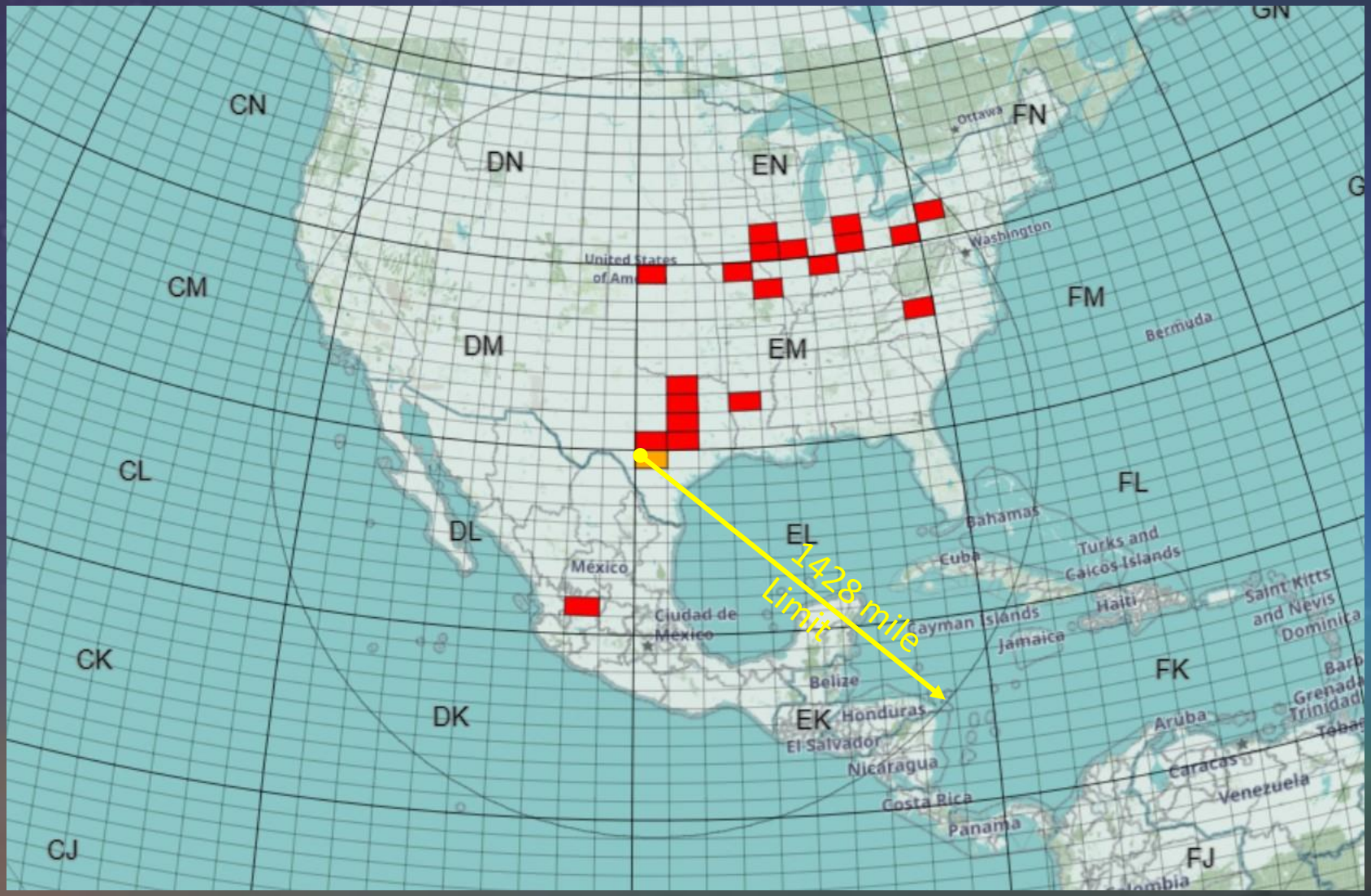
2M: Fast Graph tuned to 144.174 FT8



Logbook: 6m MSK144

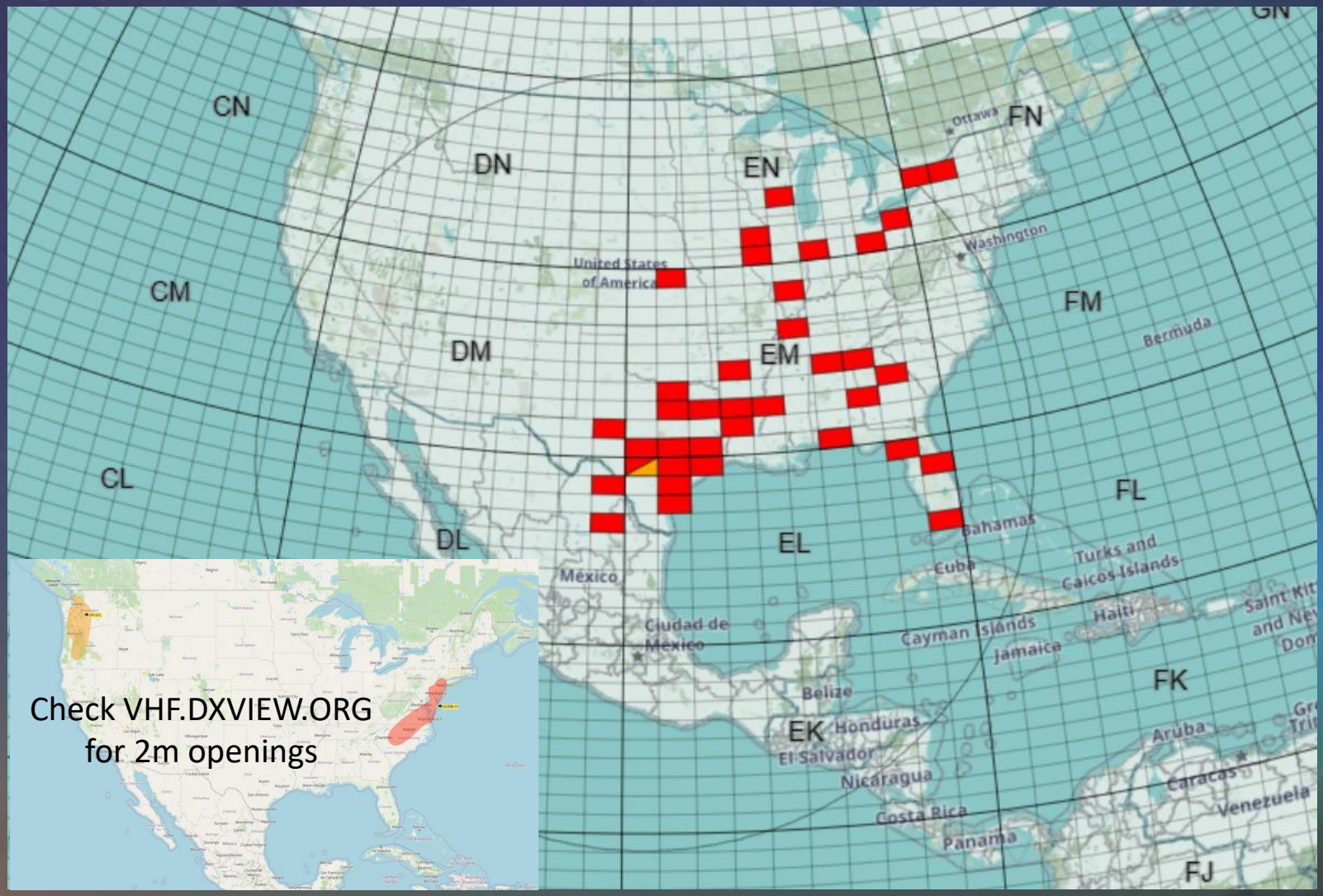


Logbook: 2m MSK144

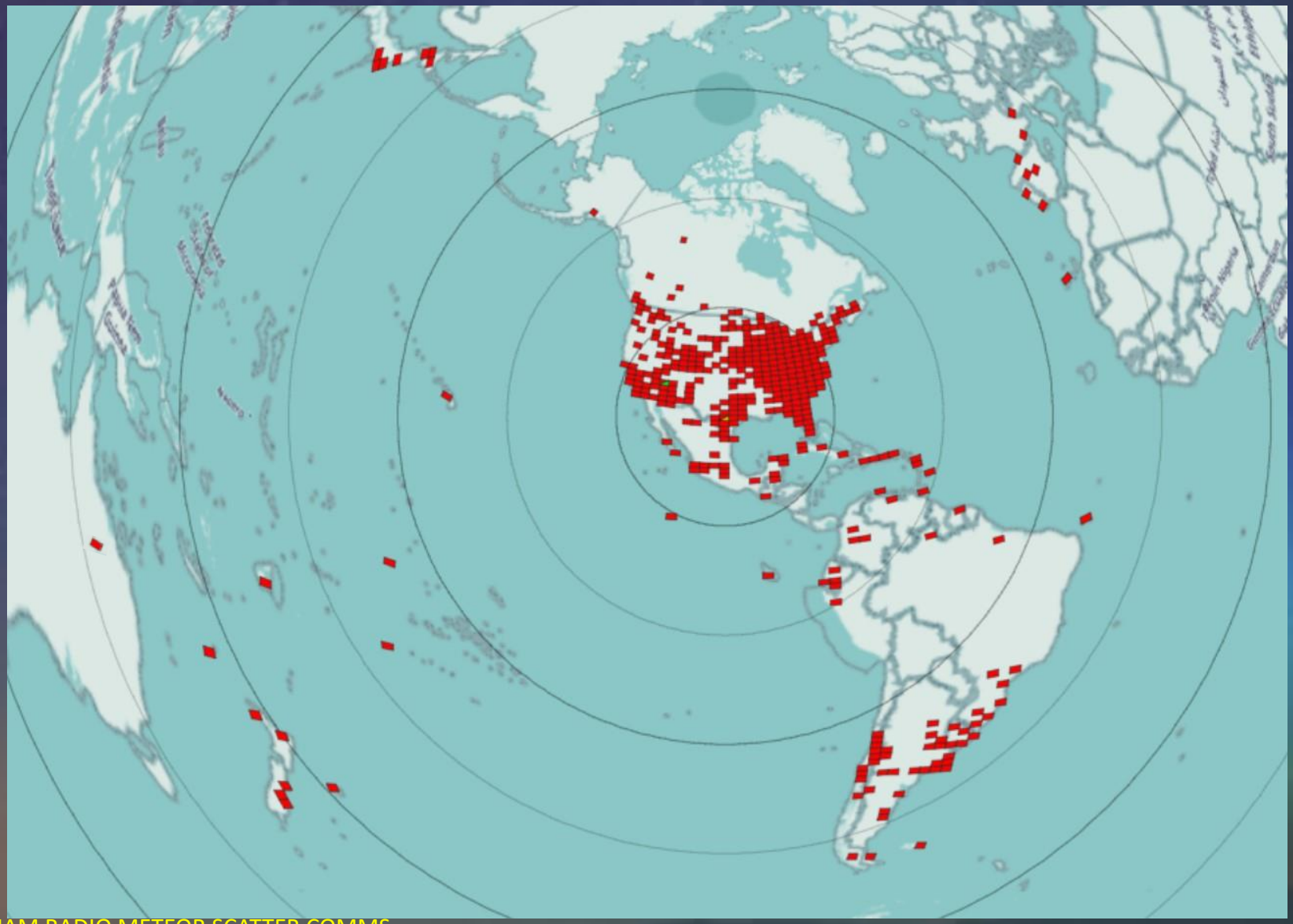


Logbook: 2m FT8 Tropo Ducting

Another reason to put up a 2m Yagi



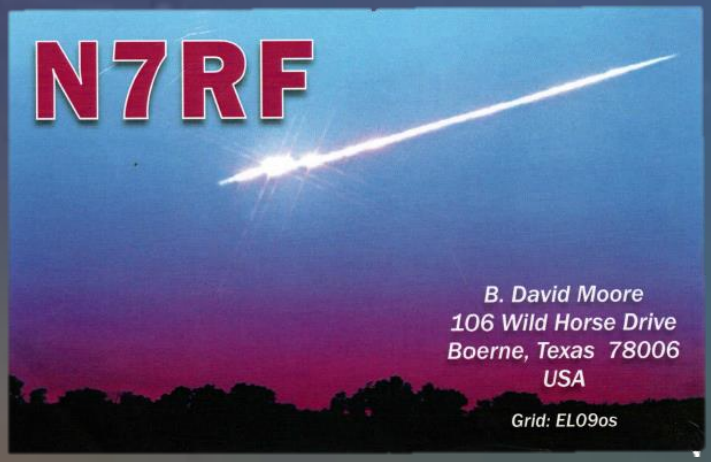
Logbook 6m FT8 Es/TE/Tropo Ducting



Questions?

QSL CARDS I USE FOR MS QSO's

Card from the 1970's QTH in Arizona



Card from the current QTH in Texas

Thank You!

n7rf@gvtc.com