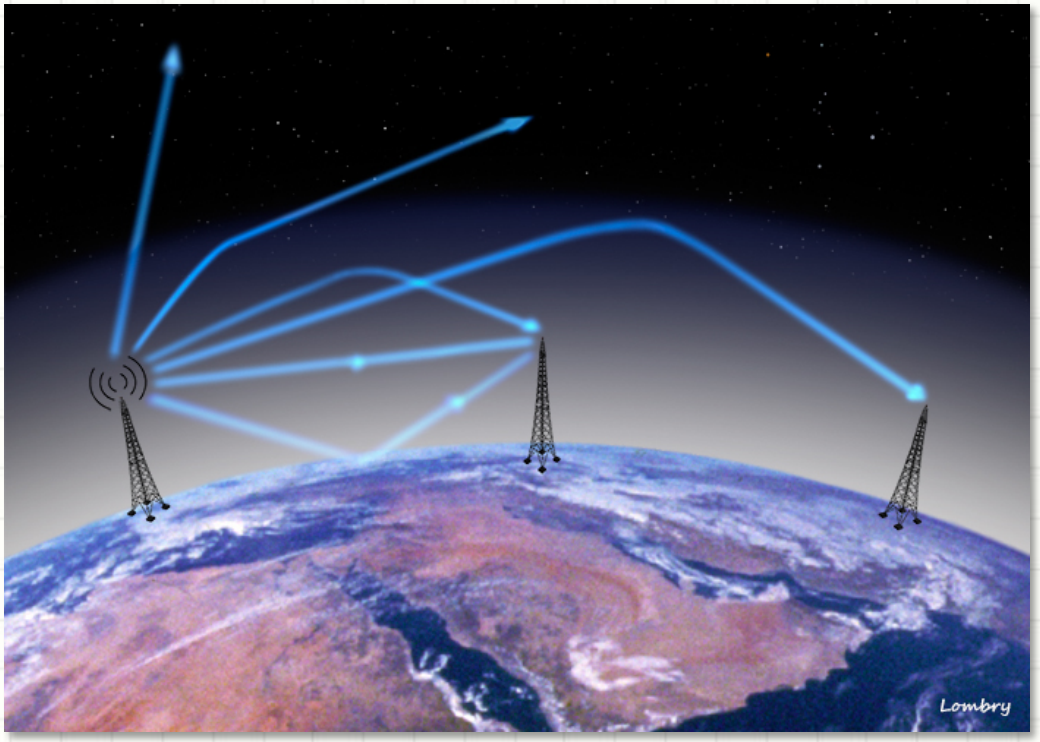
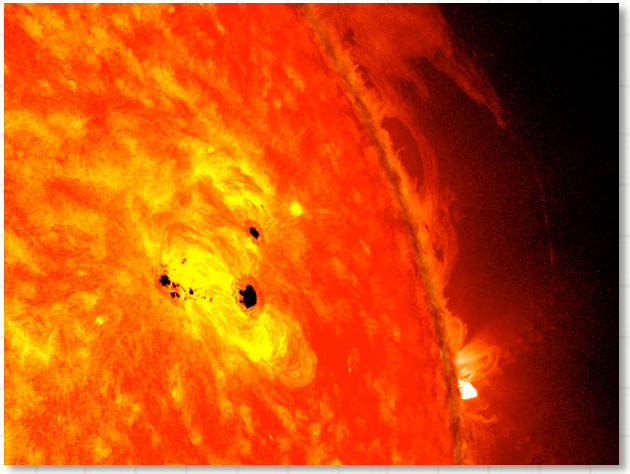


Understanding and Using Propagation to Work the World

February 2021

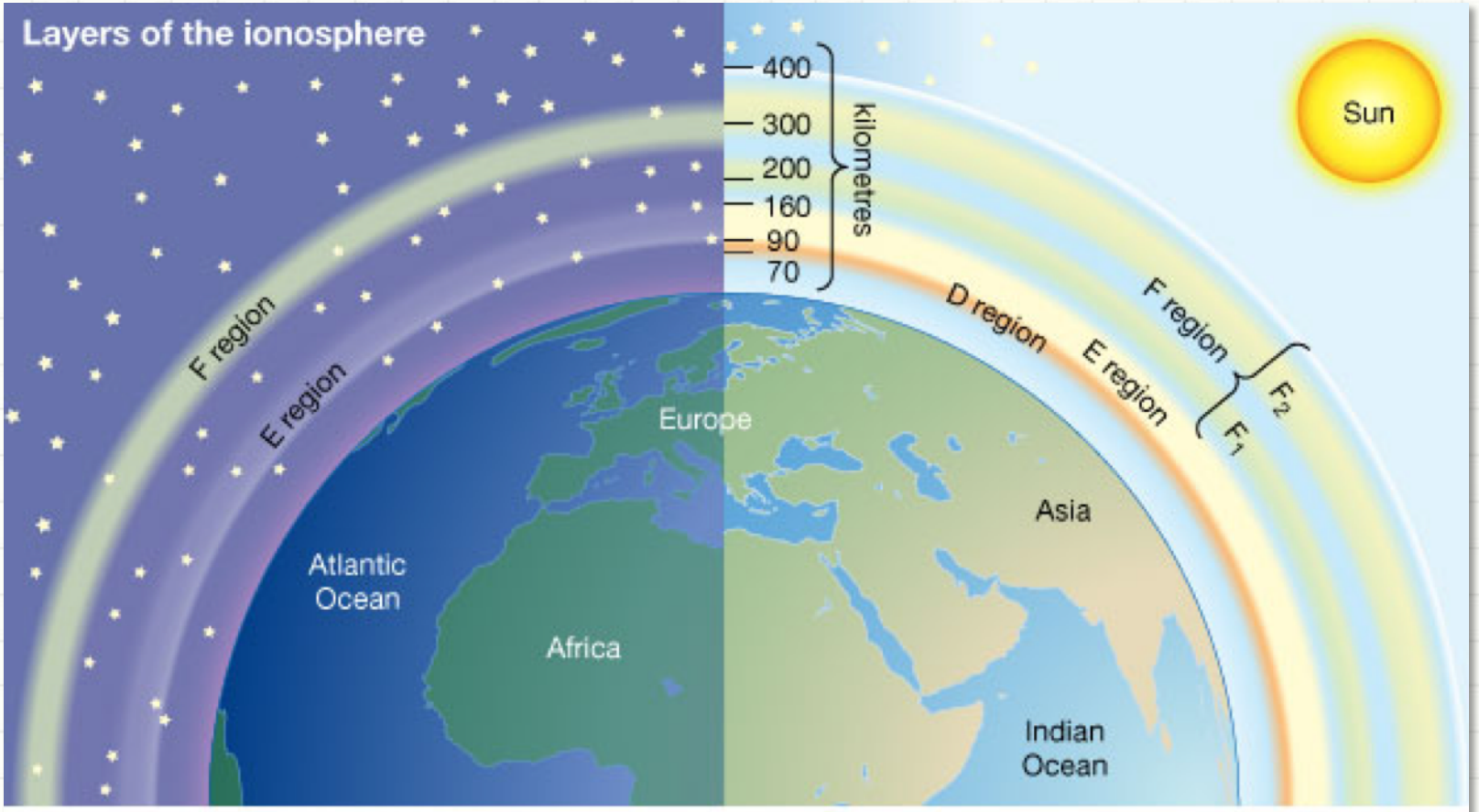
Anita Kemmerer, AB1QB

Topics



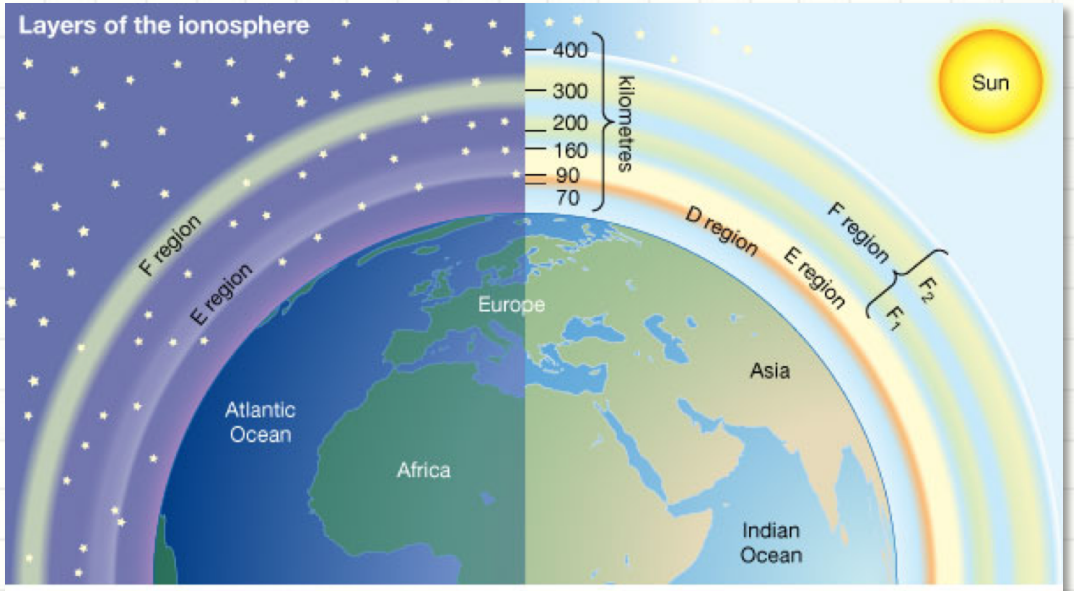
- HF Propagation
  - Its all about the Ionosphere
  - Layers of the Ionosphere
  - The Sunspot Cycle
  - Other modes: TEP, Greyline, Backscatter, and more
  - The bad: Solar Flares and CMEs and the D-Layer
  - Software Propagation Predictions
- VHF/UHF Propagation
  - 6 Meters – The Magic Band - its all about the E layer
  - 2 Meters and Tropo
  - Software Propagation Predictions

Its All About the Ionosphere



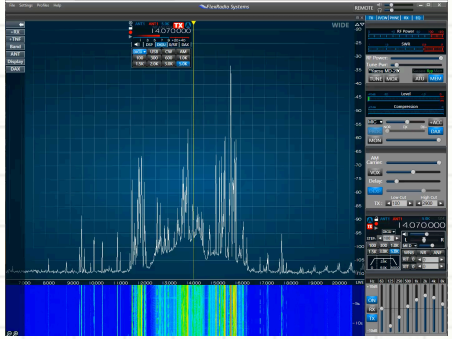
D-Layer

- The D-Layer is present during the day but goes away at night
- D-Layer absorbs low frequency HF Signals
- 160m, 80m, 40m are mostly local during the day.
- At night, D-Layer goes away, which allows for world-wide propagation on low frequency HF Bands
- AM Radio signals are also Low Frequency and that is why you hear distant AM stations at night

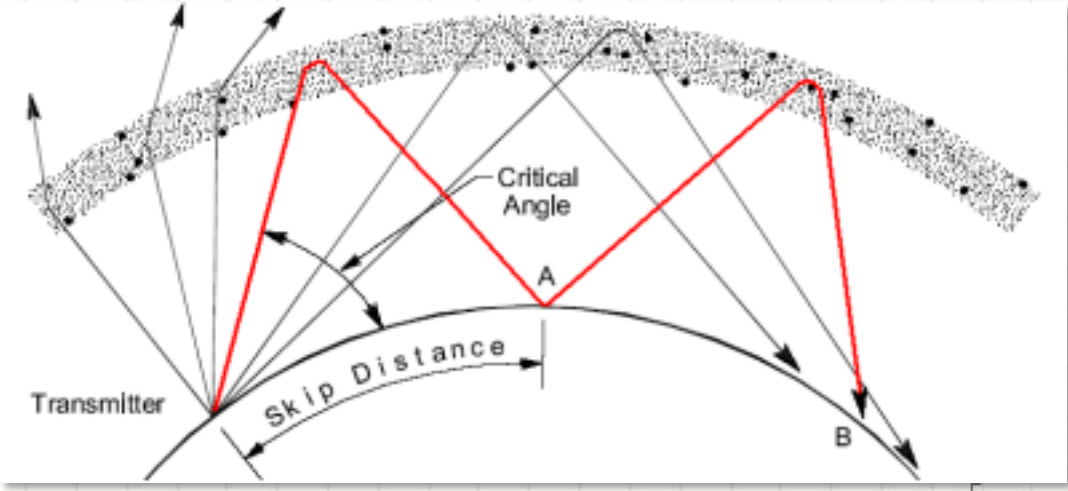


Ionospheric Refraction

Critical Angle, LUF and MUF

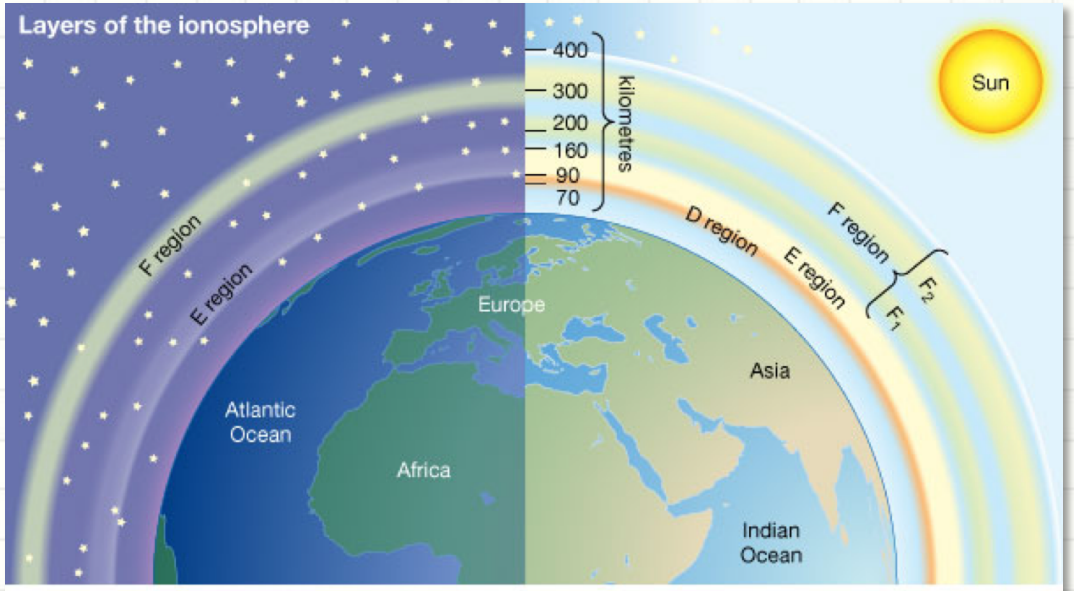


- Refracting a signal off the ionosphere is like skipping a stone over water
  - If the angle is too steep, the stone sinks, if not, it will travel a longer distance
- The highest angle at which a radio signal reflects off the ionosphere is called the Critical Angle.
  - The angle of your signal is impacted by Frequency and Antenna Take-off Angle. The point at which it reflects or passes through the ionosphere depends on sunspots, frequency, and time of day
- The MUF or Maximum Usable Frequency between two points is the highest frequency that supports a contact skipping off the ionosphere
- The LUF or Lowest Usable Frequency between two points is the lowest frequency that supports a contact skipping off the ionosphere
- Worldwide contacts are made when your signal skips off the ionosphere multiple times. But signal strength is lost each time the signal reflects off the ground.



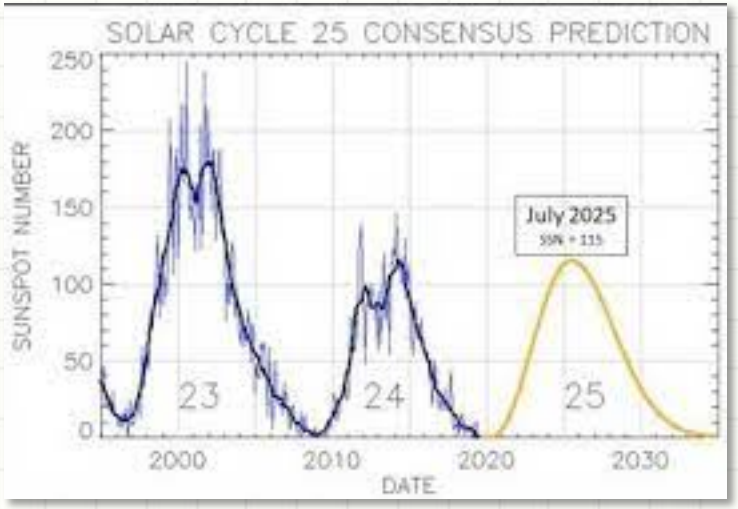
F-Layer

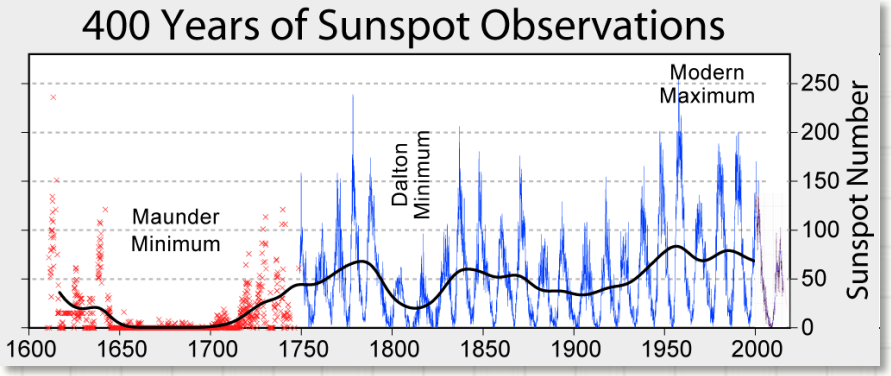
- The F-Layer is present day and night. During the day it is higher in the ionosphere and splits into 2 layers, the F1 and F2 layers
- The F-Layer provides refraction of HF signals
- The F-Layer supports higher frequency propagation with higher sunspot numbers and longer daylight hours.
- When we have high sunspots, 10 meter, 12 meter and 15 meter bands support long distance propagation during daylight hours.
- Higher frequency HF signals reflect off a higher F2 layer and travel a longer distance before returning to the ground. This is why it is easier to work California on 10 meters than it is to work Vermont from NH.



The Sunspot Cycle

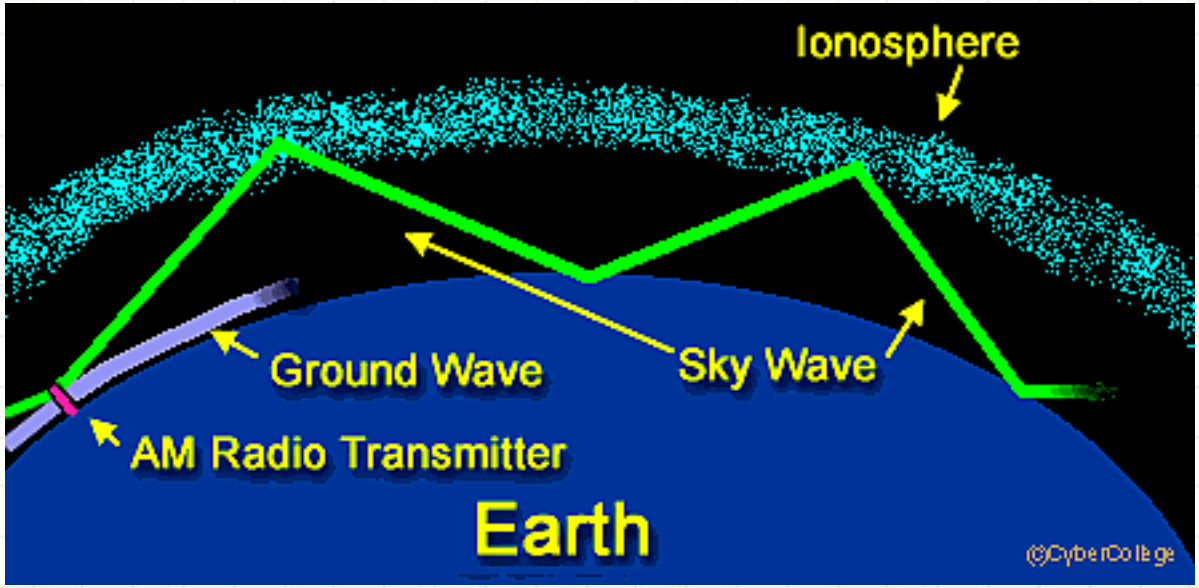
- Solar Cycle occurs over approximately 11 years
  - At peak of solar cycle, we see worldwide openings on high frequency HF bands, 10m, 12m, 15m. For strong solar cycle peaks, even 6 meters will open for F2 propagation
  - At low point of Solar Cycle, we have few or no sunspots. This causes more openings on low HF bands during the day and few openings on high HF bands.
- WFD had zero sunspots – we worked stations on 40m into the Midwest during the afternoon with 10w.
- We just entered Solar Cycle 25 and are starting to see a few sunspots
  - Predictions are all over the map, but consensus is that SC25 will be similar to SC24.
  - See Presentation by K9LA at the Propagation Summit for details on how they arrive at the predictions.





Ground Wave Propagation

- HF Contacts can be made with close stations without reflecting off the Ionosphere using Ground Wave Propagation
- Contacts are not distant – slightly further than the horizon
- Distance increases as frequency decreases
- Works best with vertical polarization at both ends of the contact.
- Example: Our 10 meter chat net during current low sunspot conditions



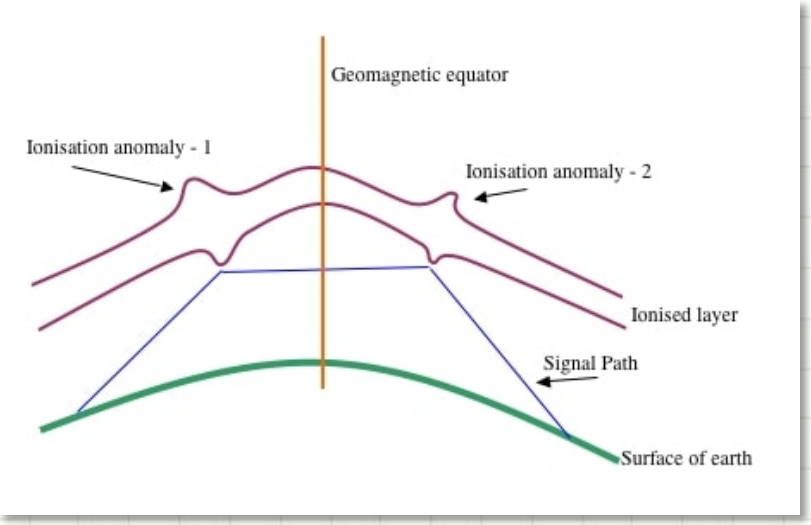
The Greyline

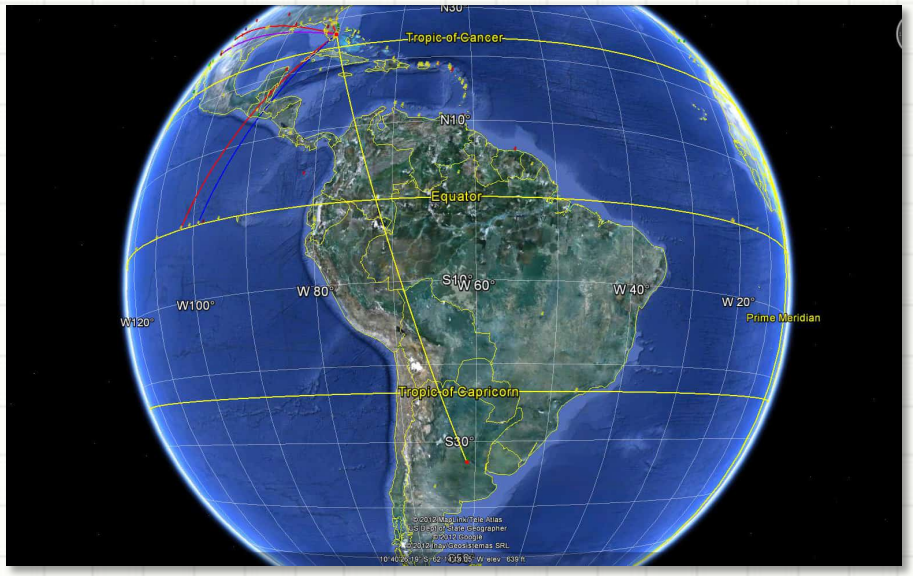
Why is the Greyline so important to Hams?

- Knowing when it is daytime or nighttime in other parts of the world can help you to know what bands are best for making contacts to that area of the world.
- Propagation enhancements are seen when both ends of the contact are on the Greyline - this is known as ***Greyline Propagation***
- Greyline enhancments benefit 40 meters and lower frequency bands

Trans-Equatorial Propagation

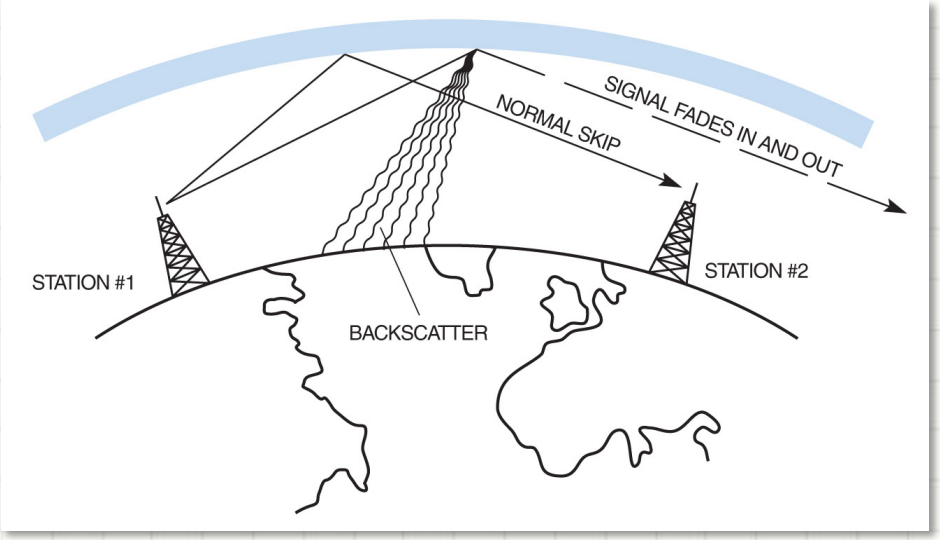
- Trans-Equatorial Propagation or TEP is a propagation mode that creates openings between a station that is North of the Equator and another station that is roughly the same distance South of the Equator
- This is why higher frequency bands like 15 meters can be open to South America during times of low sunspots.
- Tends to occur in late afternoon, after the sun has up long enough to strongly ionize the ionosphere.
- Openings are between stations up to 5000 miles apart
- Caused by heavily ionized areas on either side of the Geomagnetic Equator
- Enhancements are seen on higher frequency bands – 15m, 12m, 10m – and often combines with Sporadic E





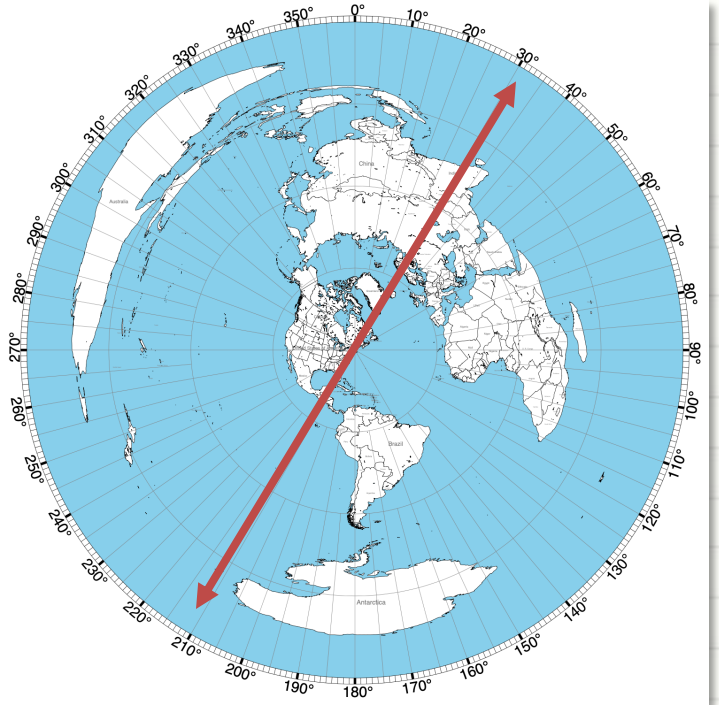
Backscatter

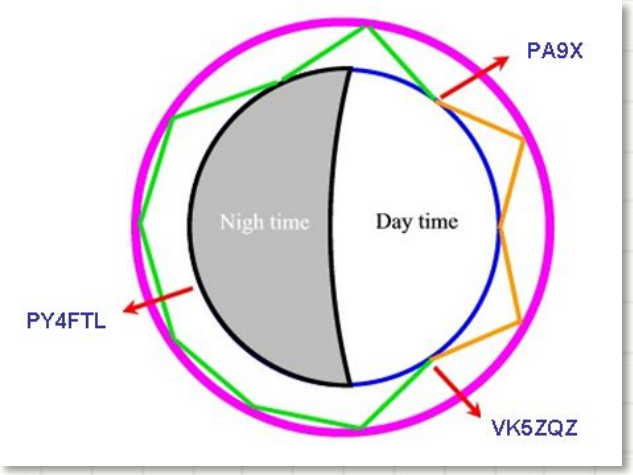
- The “Skip Zone” is the area which is beyond where you can reach with Ground-wave propagation, but closer than where you can reach with Ionospheric propagation.
- In a contest, its easy to get most states in the log except the closest ones.
- To complete the contact, stations at both ends of the contact should point their (directional) antennas toward the same place (not toward the other station) and call.
- Signal will be fluttery and fade in and out because signal is scattered over multiple paths.
- Other options to complete the call to a station in the skip zone:
  - Call on a lower frequency (80m or 40m)
  - Use a weak signal mode such as FT8 with backscatter



Long Path Propagation

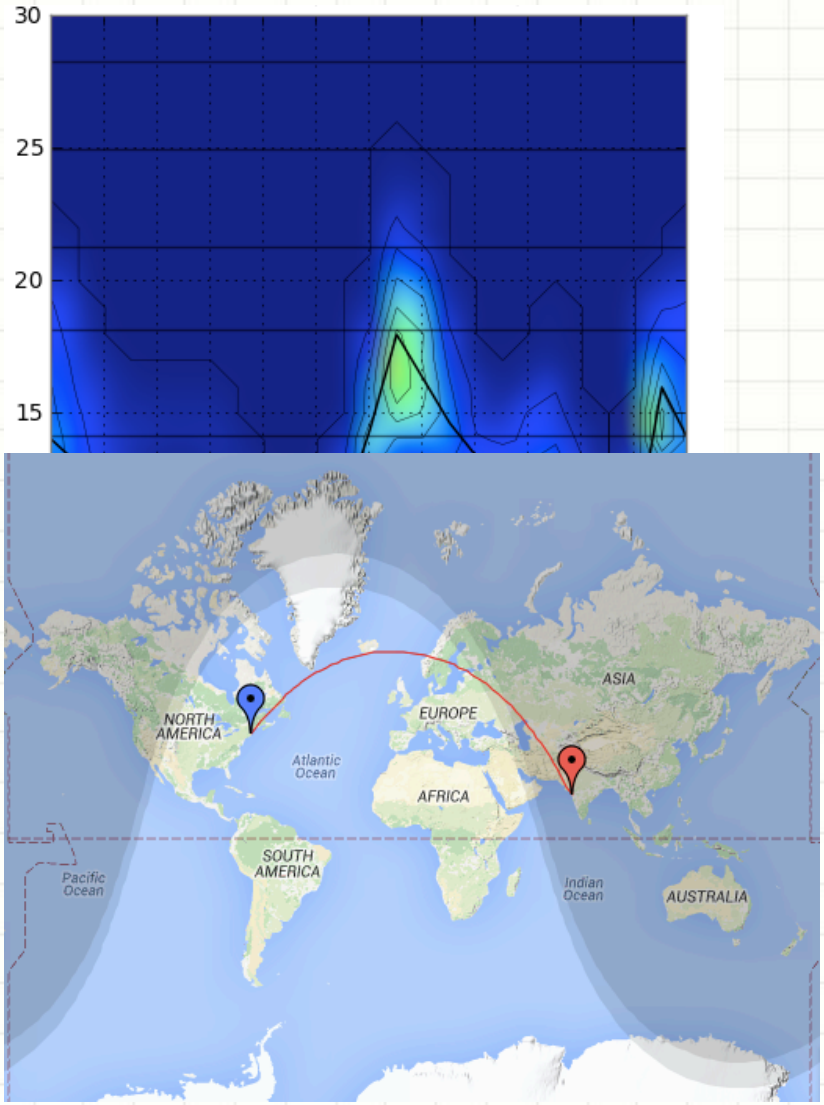
- Most contacts are made via the Short Path – you point your antenna in the direction of the shortest path to the station you want to contact
- Sometimes, you have a better chance of completing the contact if you point your antenna 180 degrees from the shortest path to the station – this is the ***Long Path***
- From the US Northeast, better long path propagation is most common for contacts to Southeast Asia.
- If both paths are open, and you do not have a directional antenna, you may hear an echo.

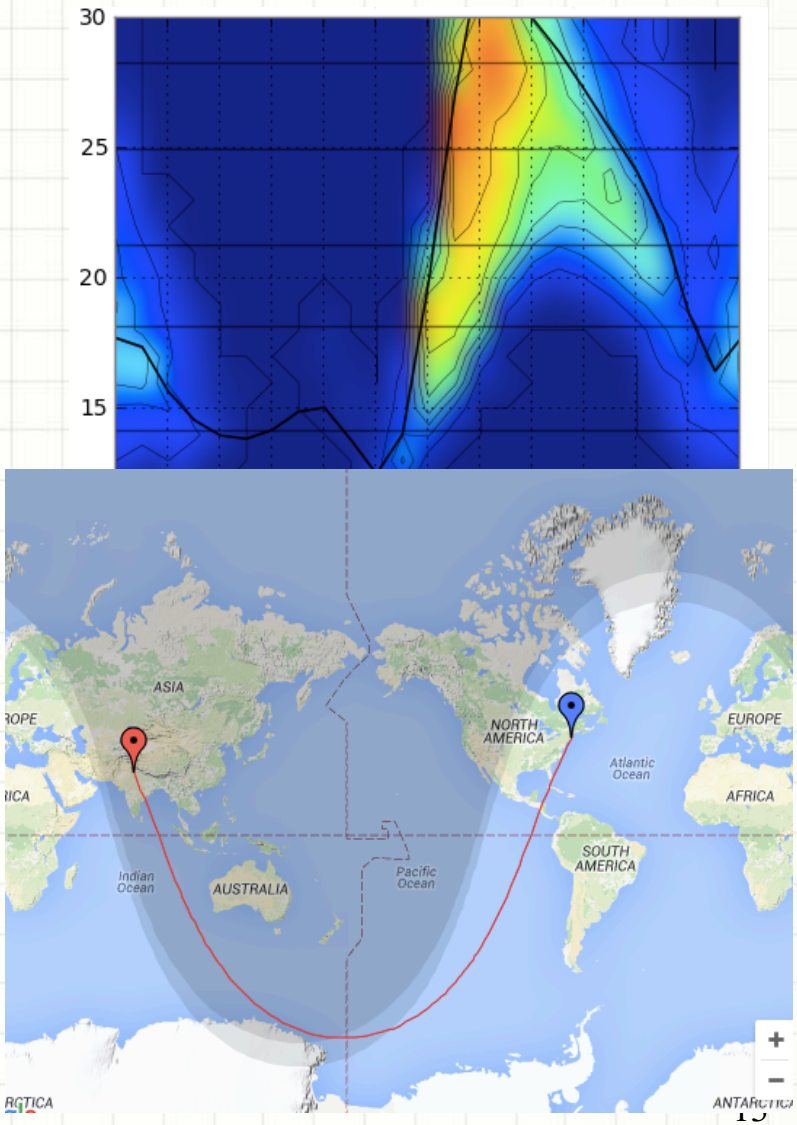




Long Path Propagation – Boston to India

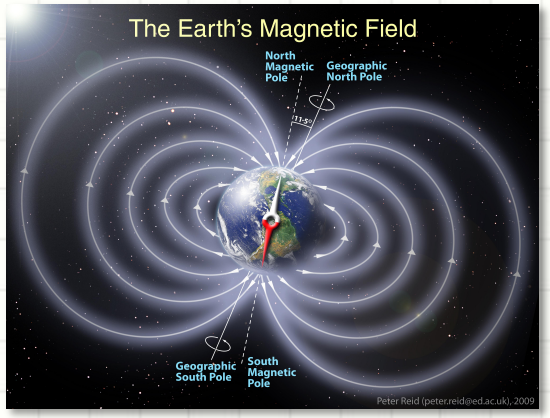
High Freq opening at 8-10 am US time – Nov 6

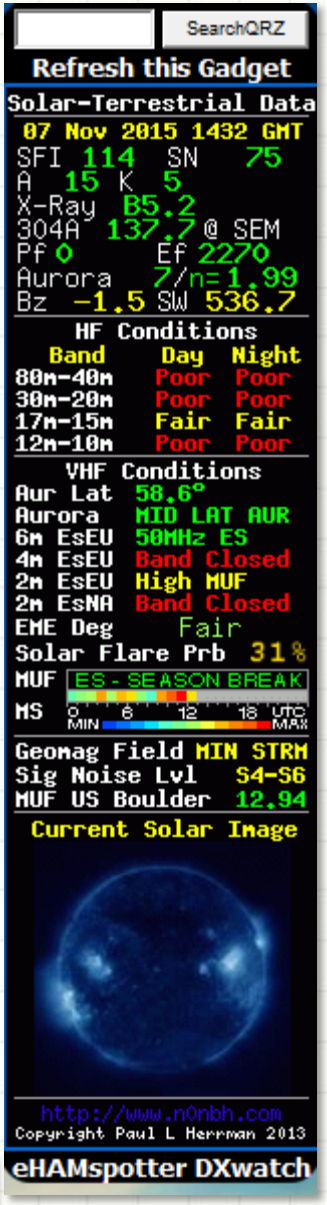




Solar Flares and CMEs – The K and A Indices

- **Solar Flare**
  - Giant Burst of X-Rays and Energy
  - Travels at the Speed of Light.
  - Takes minutes to reach Earth
- **Coronal Mass Injection (CME)**
  - Giant clouds of particles hurled into space by the Sun.
  - Takes 1-3 days to reach Earth
- **K-Index**
  - Short term measure of the disruption of the Earth's magnetic field.
  - Higher K-Index means more disruption.
- **A-Index**
  - Long term measure of the disruption of the Earth's magnetic field.

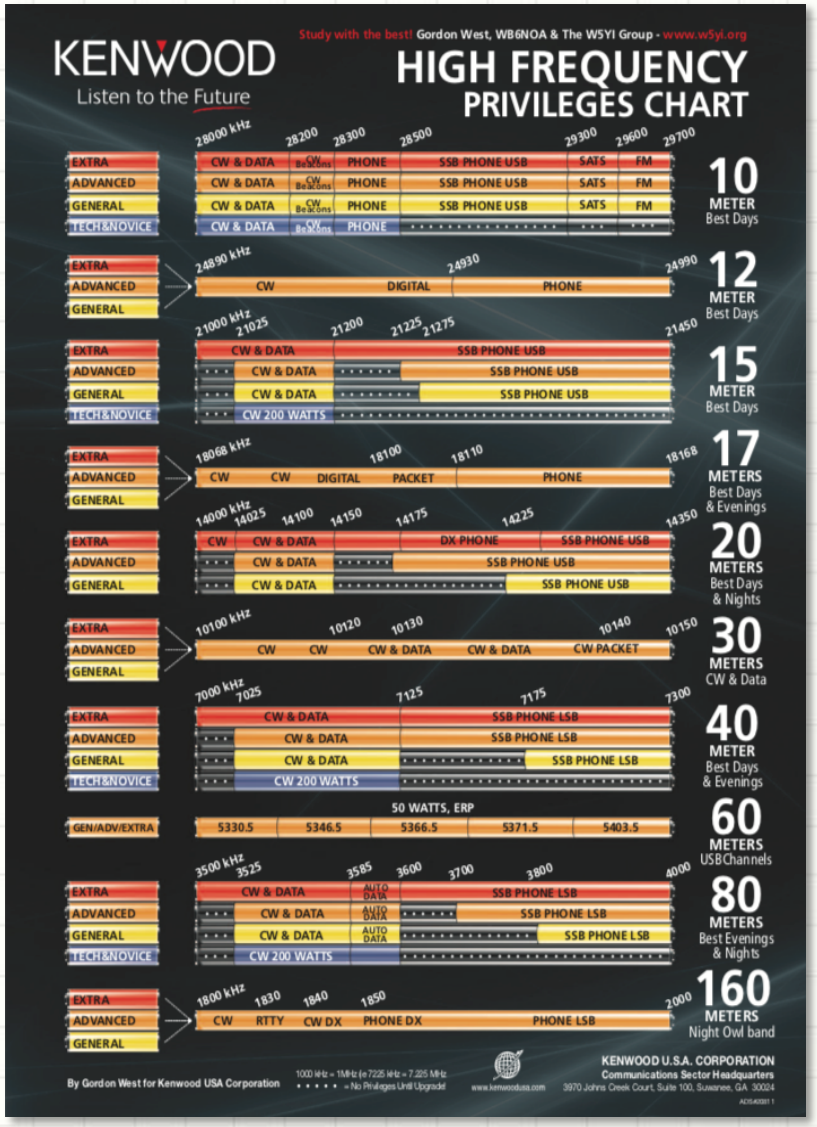




Both Solar Flares and CMEs can disrupt communication on the HF bands by disrupting the earth's magnetic field.

How/When to Work the HF Bands

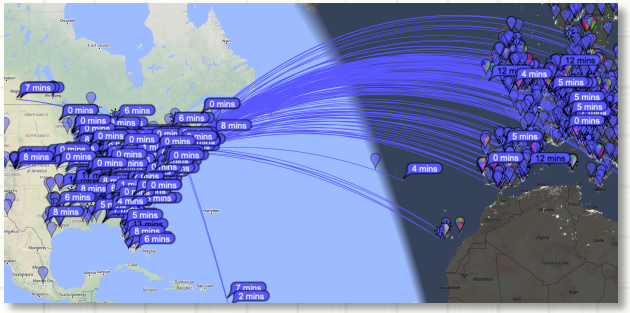
- 160 meters
  - Best when its dark out
  - Best at Winter Solstice, Low Sunspots
  - Can work other times with good recv. antenna (SFD)
- 80 meters
  - Nearby contacts any time
  - DX- near dusk with Low Sunspots – after dark with high sunspots - best at Winter Solstice
- 40 meters
  - Low sunspots – open to Midwest most of the day. Long distance opens early morning or towards dusk
  - High sunspots – DX open when its dark
- 20 meters
  - Open to DX under when sunspots are low or high
  - Low Sunspots – closes at night as 40 and 80 open
- 15 meters
  - Opening's noon to evening during good sunspot conditions
  - Sometimes open to South America and Caribbean during afternoon low sunspots
- 10 meters
  - Openings in US during E-Skip season
  - Daytime Long DX openings during high sunspot number

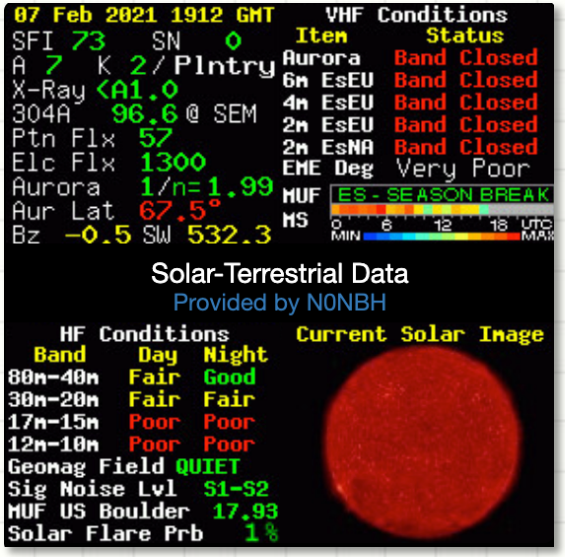


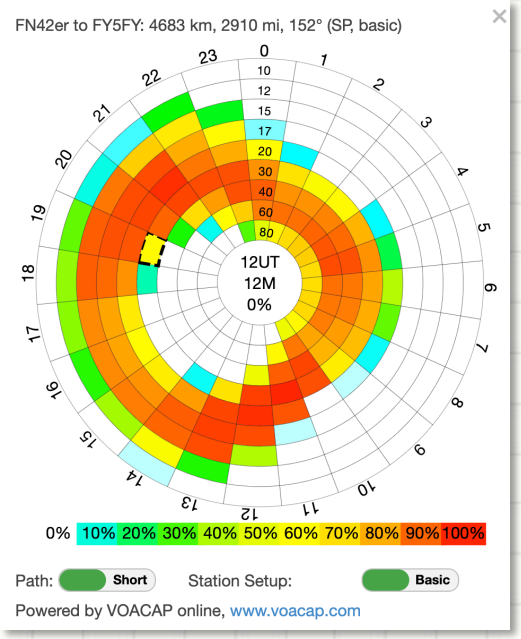
Be aware of the greyline – what bands are open for the DX station as well for you?

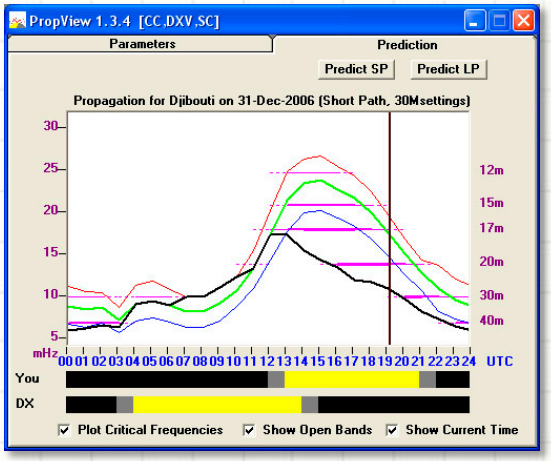
Using Software to Determine HF Propagation

- Propagation in a Nutshell - http://www.hamqsl.com/solar.html
- DX Summit – http://dxsummit.fi
- VOACAP - https://www.voacap.com/
- DX Lab Prop View - https://www.dxlabsuite.com/propview/
- PSK Reporter - https://pskreporter.info/pskmap.html
- Reverse Beacon Network - http://beta.reversebeacon.net/main.php
- WSPR http://wsprnet.org/drupal/wsprnet/map
- Operate in a Contest – or Review Contest Logs - https://www.cqww.com/publiclogs/



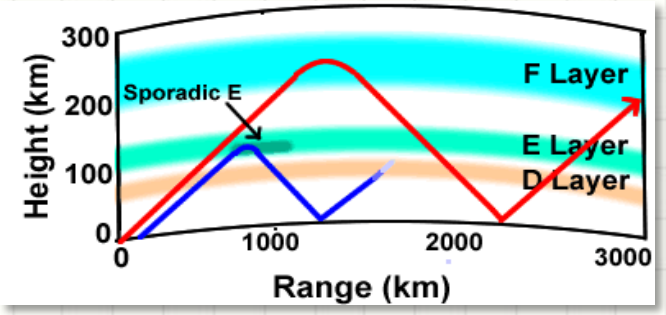


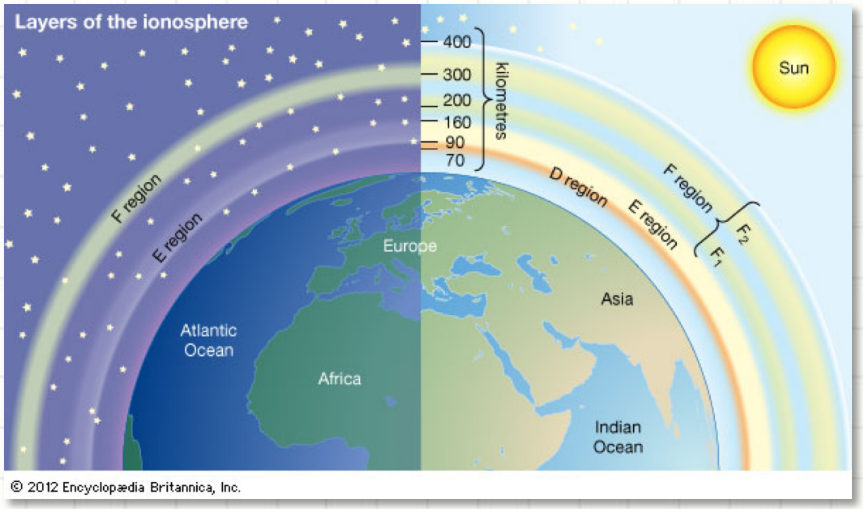




VHF Propagation - Sporadic E

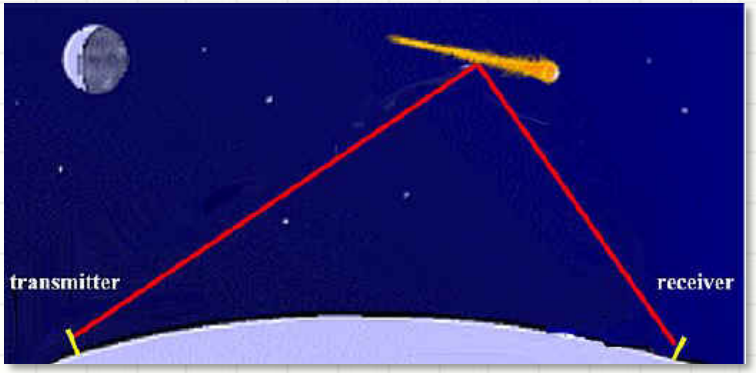
- Sporadic E propagation provides openings on the 6 meter band and sometimes the 10 meter and 2 meter bands
- Propagation can be seasonal
  - Main season takes place May through July
  - There are are also openings in November/December
- Openings and easily come and go. Need to make brief QSOs when there is an opening. Get/Give Callsign and Grid Square first.
- This is why 6 meters is called the ***Magic Band***
- The E-Layer is lower in the ionosphere, so one hop for a single refracting off the E-later is only around 1200 miles. Contacts tend to be within the US or to Europe.
- FT8 has taken over 6 meters
- If 6 meters is open, check 10m
- Openings can be day or night

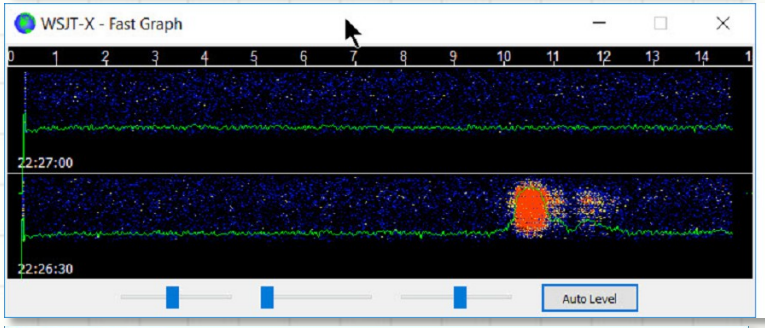


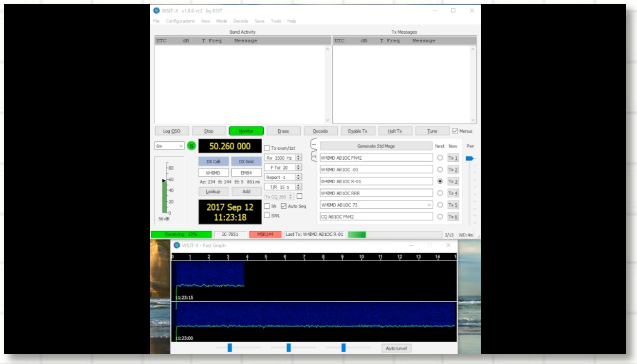


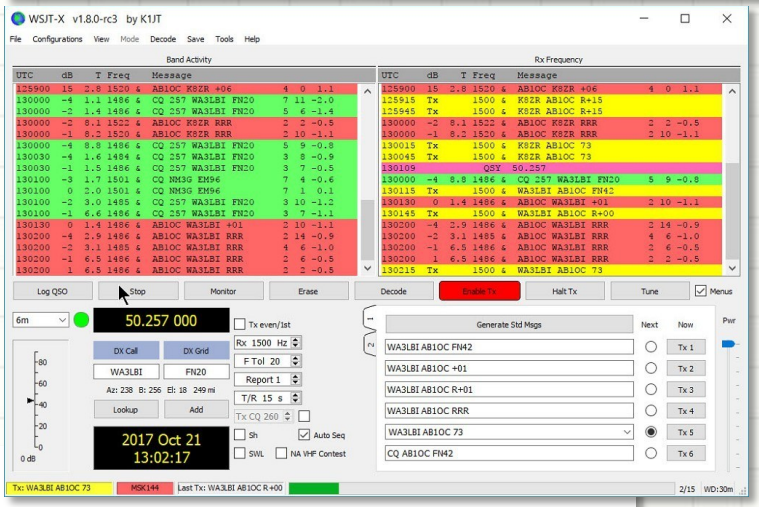
Meteor Scatter

- Meteors create short propagation enhancements when they burn up in the atmosphere
- These short propagation bursts enable very brief (approx. 1-5 sec) propagation on the 6 meter band
- The WSJT-X digital mode MSK144 is well suited for making Meteor Scatter Contacts
- The best time is during a meteor shower, but contacts can be made almost any morning.
- Best time is early morning just before sunrise









When is the next meteor shower?

Lyrids

Status: Active from April 16th to April 30th

Peak: Apr 21-22 2021 (Moon 68% full.)

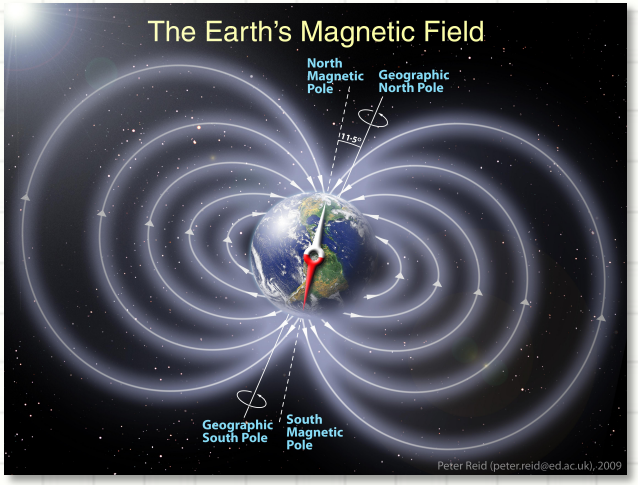
eta Aquariids

Status: Active from April 19th to May 28th

Peak: May 4-5 2021 (Moon 38% full.)

Auroral Propagation

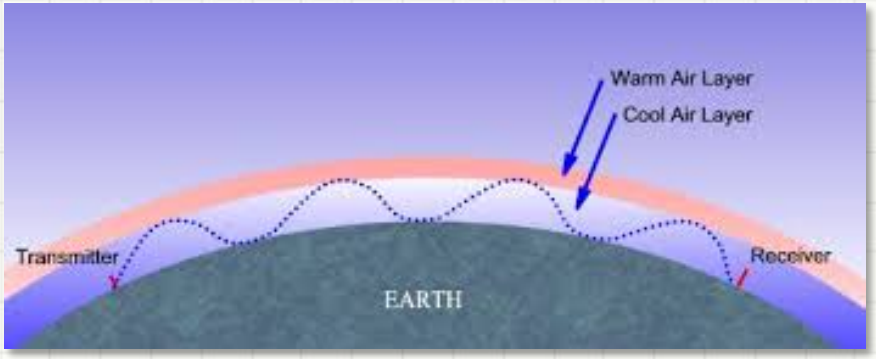
- The same Geomagnetic disturbances that wreak havoc on the HF bands can cause openings on the Magic Band
- An Aurora can cause openings on 6 meters.
- Everyone points their antenna north – contacts can be made with the US and Canada.
- Audio from Auroral propagation will be very distorted. There is almost no tone.
- CW and SSB contacts can be made using Auroral propagation.

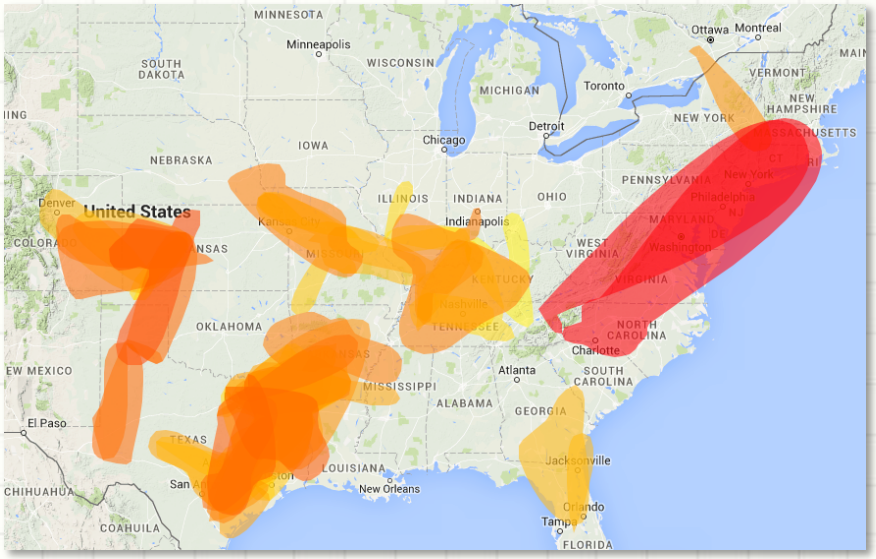


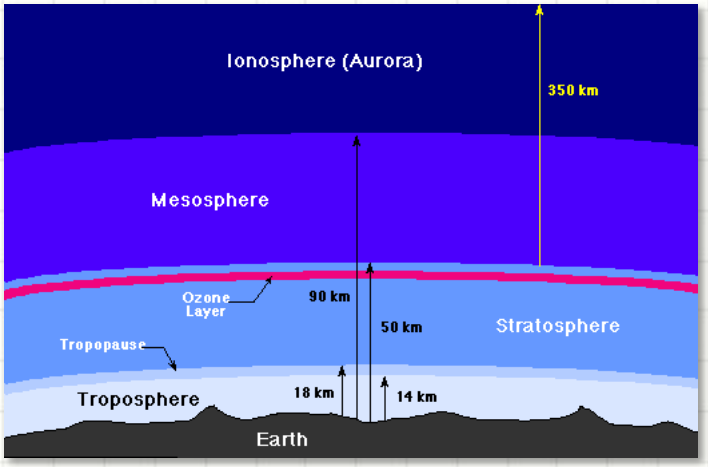
Aurora CW

Tropospheric Ducting

- Normally, 2 meter propagation is line of sight.
- Distances are around 25 miles – you can go 50 miles via a repeater.
- When weather conditions cause a temperature inversion, a tropospheric duct will form.
- This allows 2 meter signals travel much farther than normal.
- Maximum distances are around 300 miles, as Troposphere is much lower than the Ionosphere.
- This is most common over bodies of water.
- Can combine with E-Skip

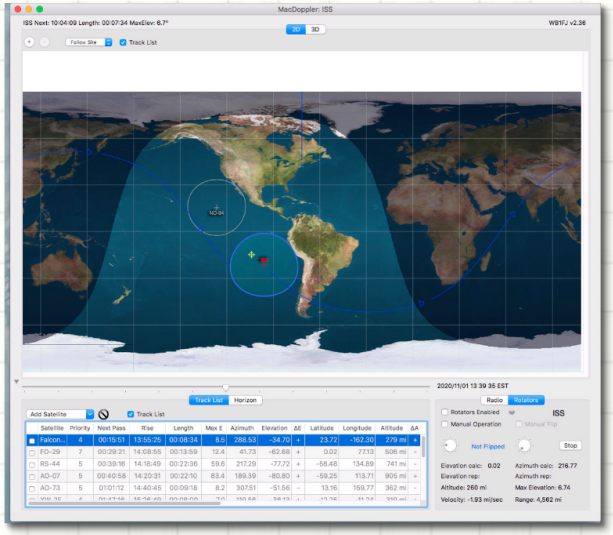






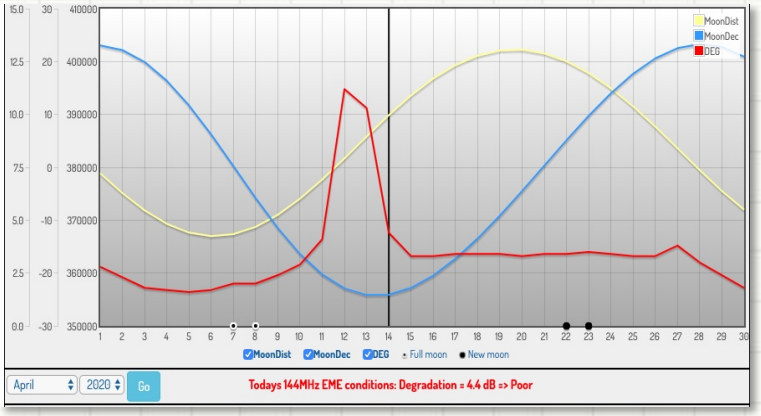
Satellites

- Make contacts over a Repeater on a Low Earth Orbit Satellite
- Can make contacts any time there is a satellite overhead
- Not dependent on propagation conditions or sunspot cycles
- Can make contacts with an HT or a fixed station with 2 meter / 70 cm antennas
- Can listen to Astronauts on the ISS making contacts with students when AB1OC is the telebridge station
- To get started, see the Tech Night Video ***How to Get Started with Satellites*** at https://www.n1fd.org/tech-night/



What is EME? How Does It Work?

- EME or Moon Bounce Communications uses signals bounced off the Moon to make DX contacts on the VHF and higher bands
- About ½ of the globe can "see" the moon at any point in time making DX possible (and common)
- Bands from 6m through 10 GHz+ are used
  - 2m most common, also 6m, 70cm
- Most popular EME mode is JT65x Digital. CW is still used but requires BIG antennas and LOTS of power.
  - Its possible to make a 2m JT65x contact with 1 large or 2 medium Yagis and 200w - 500w of Tx power
- What impacts EME Propagation?
  - The moon is not a very good reflector + **Libration Fading** (multipath effect)
  - **Faraday Rotation** - ionosphere causes polarity changes which result in deep fading.
  - Distance of the Moon from Earth (Apogee vs. Perigee)

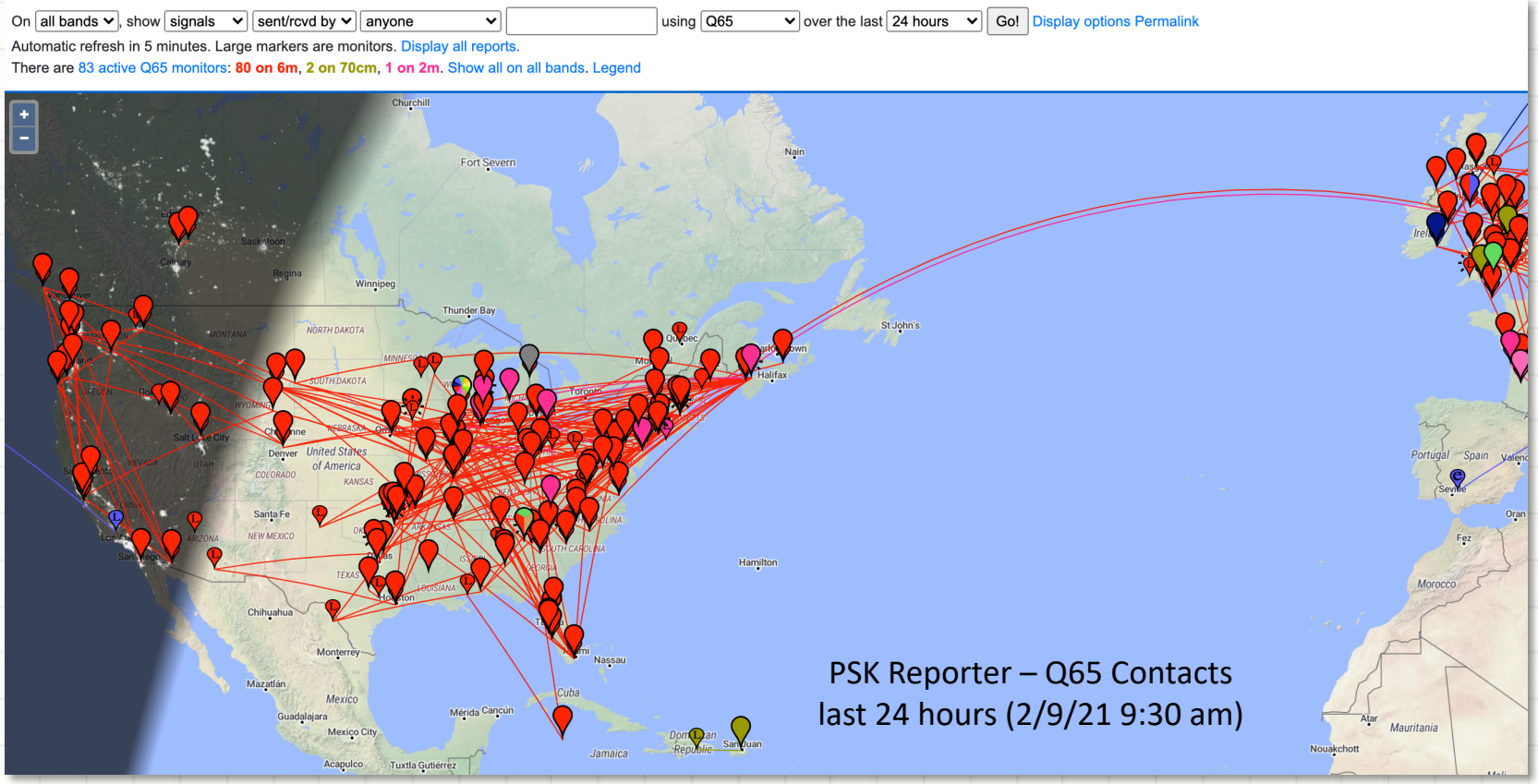


EME Degradation (lower is better)

See Tech Night ***Getting Started with EME Communications*** for more information

Q65 – New WSJT-X Mode

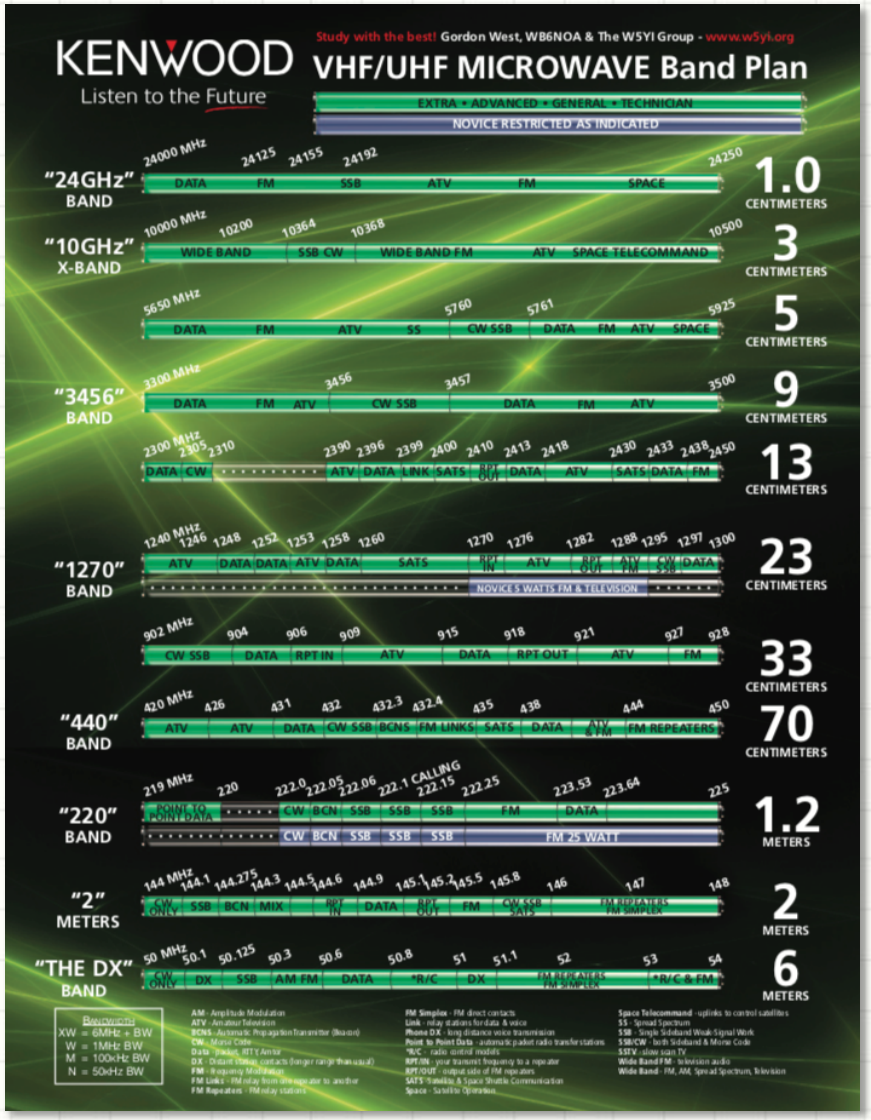
- Q65 is a new WSJT-X mode that was just made available in WSJT-X 2.4.0-rc1
- In Joe Taylor's words "a digital protocol designed for minimal two-way QSOs over especially difficult propagation paths."
- https://physics.princeton.edu/pulsar/k1jt/Q65_Quick_Start.pdf
- Example applications:
  - Ionospheric scatter on the 6 m band
  - EME, troposcatter, rain scatter, …



PSK Reporter – Q65 Contacts last 24 hours (2/9/21 9:30 am)

How/When to Work the UHF/VHF Bands

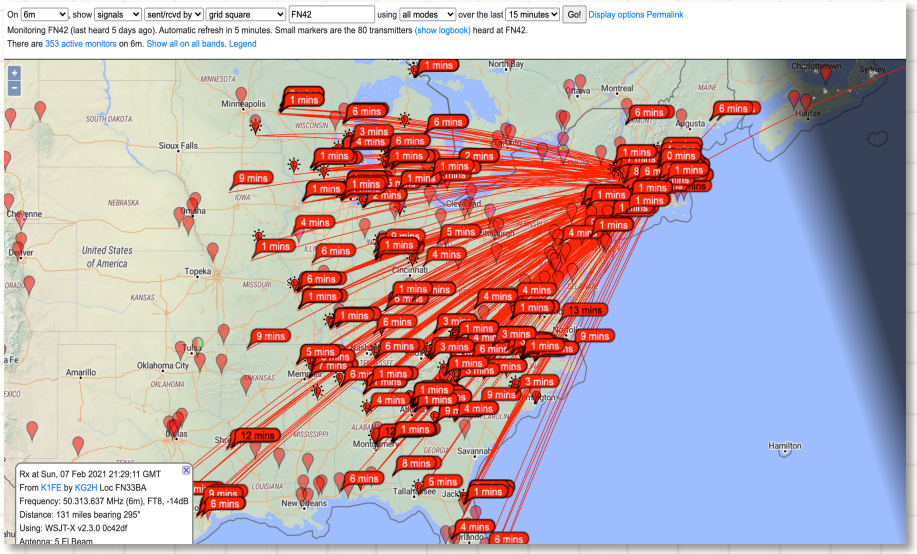
- 6 Meters
  - Sporadic E – Summer and Winter
  - Meteor Scatter – Mornings and during Meteor Showers
  - Aurora – during Geomagnetic storms
  - Few Repeaters – Any time
- 2 Meters
  - Weak Signal/Tropo – when weather conditions permit
  - Satellites – Any time there is a pass
  - EME – Conditions vary monthly
  - Repeaters – Any Time
- 70 Centimeters
  - Weak Signal
  - EME – Conditions vary monthly
  - Satellites – any time there is pass
  - Repeaters – Any time

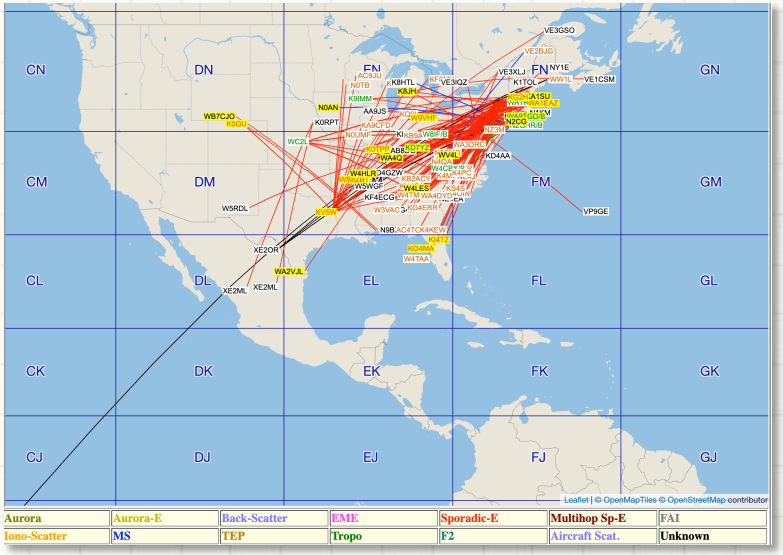


WSJT-X Modes (FT8, FT4) are primary weak signal modes on these bands

Using Software to Determine VHF Propagation

- DX Maps – 6 Meters- https://www.dxmaps.com/spots/mapg.php
  - Can generate email alarms when there is an opening
- PSK Reporter – 6 meter FT8 - https://pskreporter.info/pskmap.html
- Hepburn Maps - https://www.dxinfocentre.com/tropo.html
- VHF Propagation Maps - http://aprs.mennolink.org/





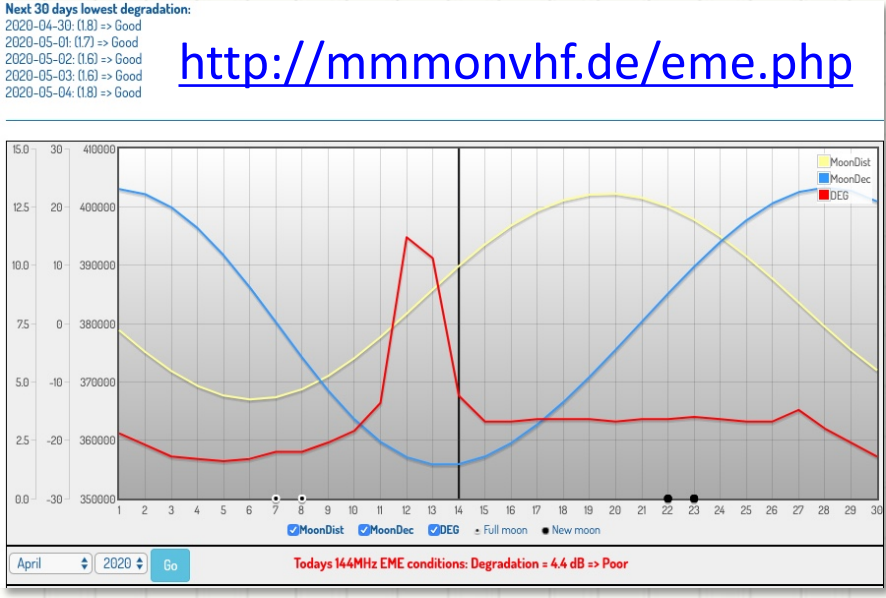
Thank You!

Supplemental Information

Finding Contacts, Prop & Signal Assessment

https://www.chris.org/cgi-bin/jt65emeA

WSJT Sked Page



http://mmmonvhf.de/eme.php

EME Degradation (lower is better)

Freq	Date	Time	Signal	DF	DT		Call	Loc	Pol	Mode	Spotter
144.125	10-Apr	2159	-22	+297	2.6	CQ	IK3VZO	JN55	68	JT65b	S51ZO
144.122	10-Apr	2154	-20	- 064	1.6	CQ	ZL3NW	RE66	0	JT65b	IK2DDR
144.122	10-Apr	2140	-25	+001	2.5	CQ	ZL3NW	RE66	40	JT65b	S51ZO
144.134	10-Apr	2132	-20	- 037	2.8	CQ	ZL2MQ	RF80	50	JT65b	S51ZO
144.132	10-Apr	0535	-21	- 078	2.5	CQ	AI1K	DM34	168	JT65b	PA9RX
144.114	10-Apr	0536	-24	- 362	2.2	CQ	ON4GG	JO20	99	JT65b	PA9RX
144.118	10-Apr	0518	-20	+115	2.3	CQ	IV3RYX	JN65	77	JT65b	PA9RX
144.130	10-Apr	0446	-24	+490	2.4	CQ	HA8CE	KN06	76	JT65b	PA9RX
144.126	10-Apr	0422	-24	- 318	2.7	CQ	OH1HSC	KP10	91	JT65b	PA9RX
144.133	10-Apr	0421	-23	- 067	2.6	CQ	K9MRI	EN70	156	JT65b	PA9RX
144.129	10-Apr	0416	-18	+467	2.7	QRZ	I3MEK	JN55	33	JT65b	PA9RX

LiveCQ EME RBN
https://www.livecq.eu/latest.asp

Some useful tools for:

- Deciding when to operate
- Gauging conditions
- Arranging contacts