How KC5RUO uses VOACAP to Determine the Best HF Frequency to Connect to a Distant-End Station

VOACAP = VOICE OF AMERICA COVERAGE ANALYSIS PROGRAM

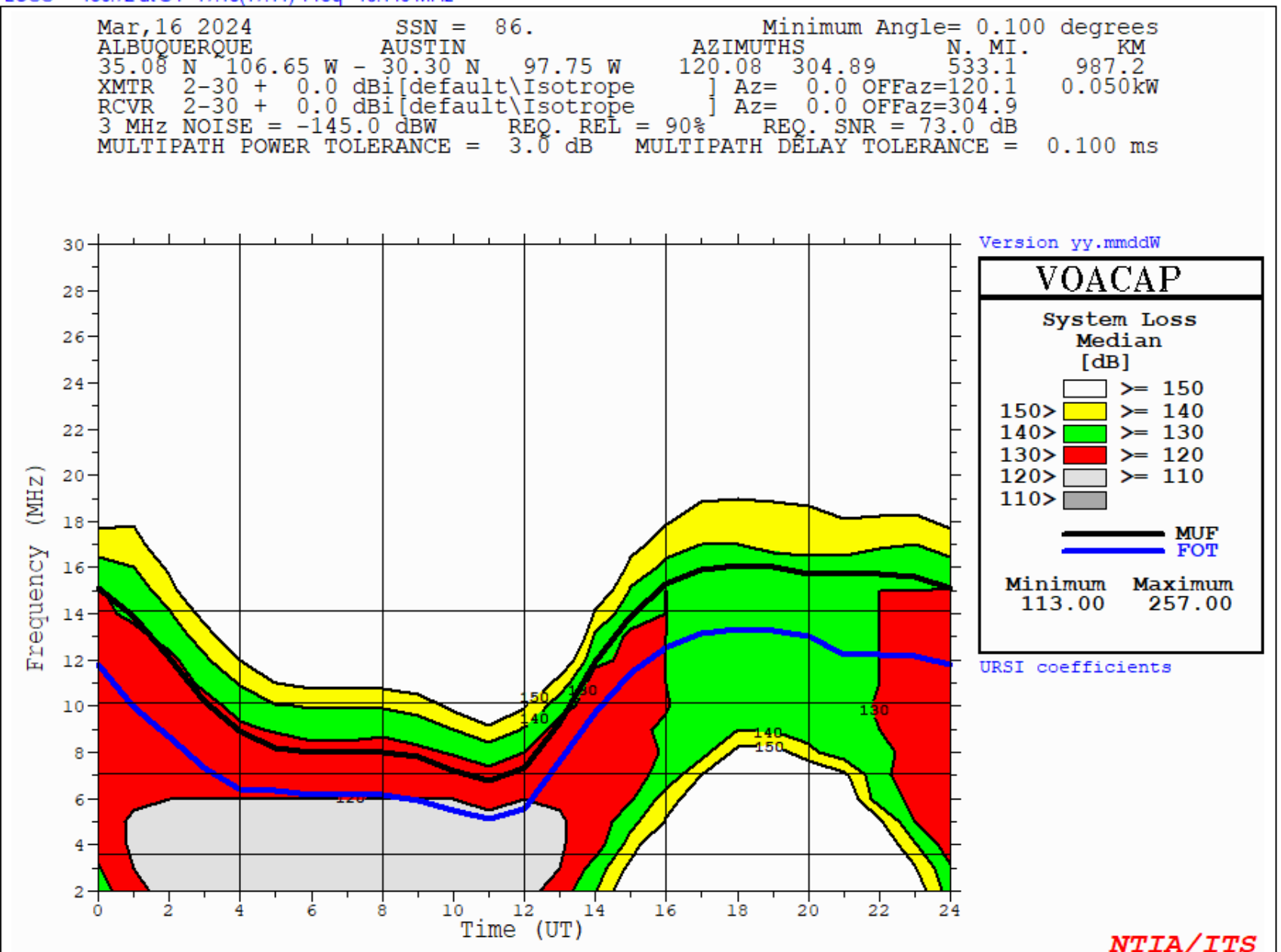
Jim Frazier, KC5RUO

jimfraziernm@comcast.net

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

LOSS = 136.72 at UT=17.18(17:11) Freq= 10.149 MHz



VOACAP is a prediction tool that predicts the signal path loss between the transmitter and the receiver.

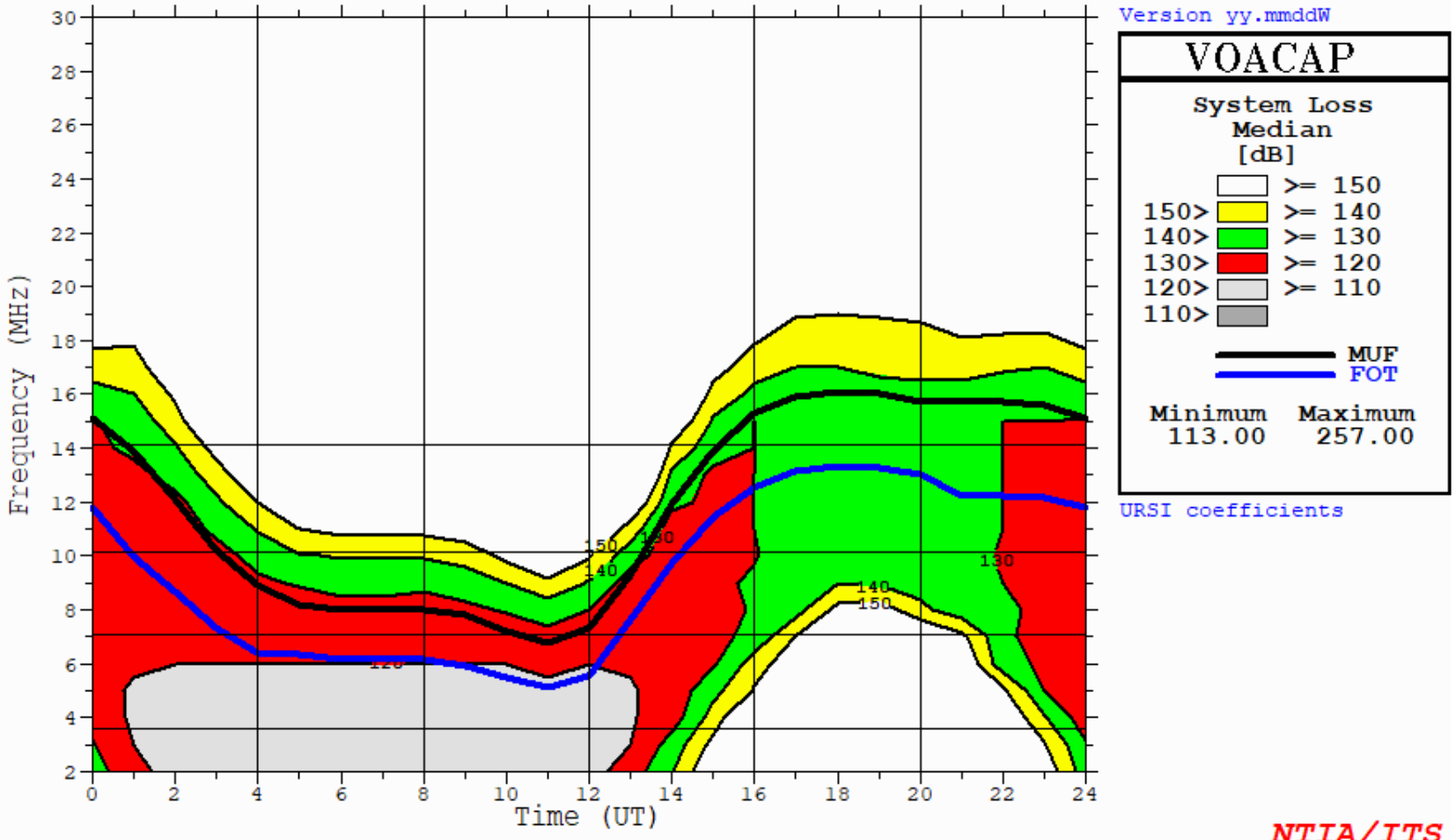
VOACAP is a signal path loss calculator that displays the best HF frequencies between a transmitter and receiver station over time of day.

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

LOSS = 136.72 at UT=17.18(17:11) Freq= 10.149 MHz

```
Mar,16 2024          SSN =  86.                Minimum Angle= 0.100 degrees
ALBUQUERQUE         AUSTIN                 AZIMUTHS          N. MI.      KM
35.08 N  106.65 W - 30.30 N   97.75 W    120.08  304.89      533.1     987.2
XMTR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=120.1    0.050kW
RCVR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=304.9
3 MHz NOISE = -145.0 dBW     REQ. REL = 90%    REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms
```



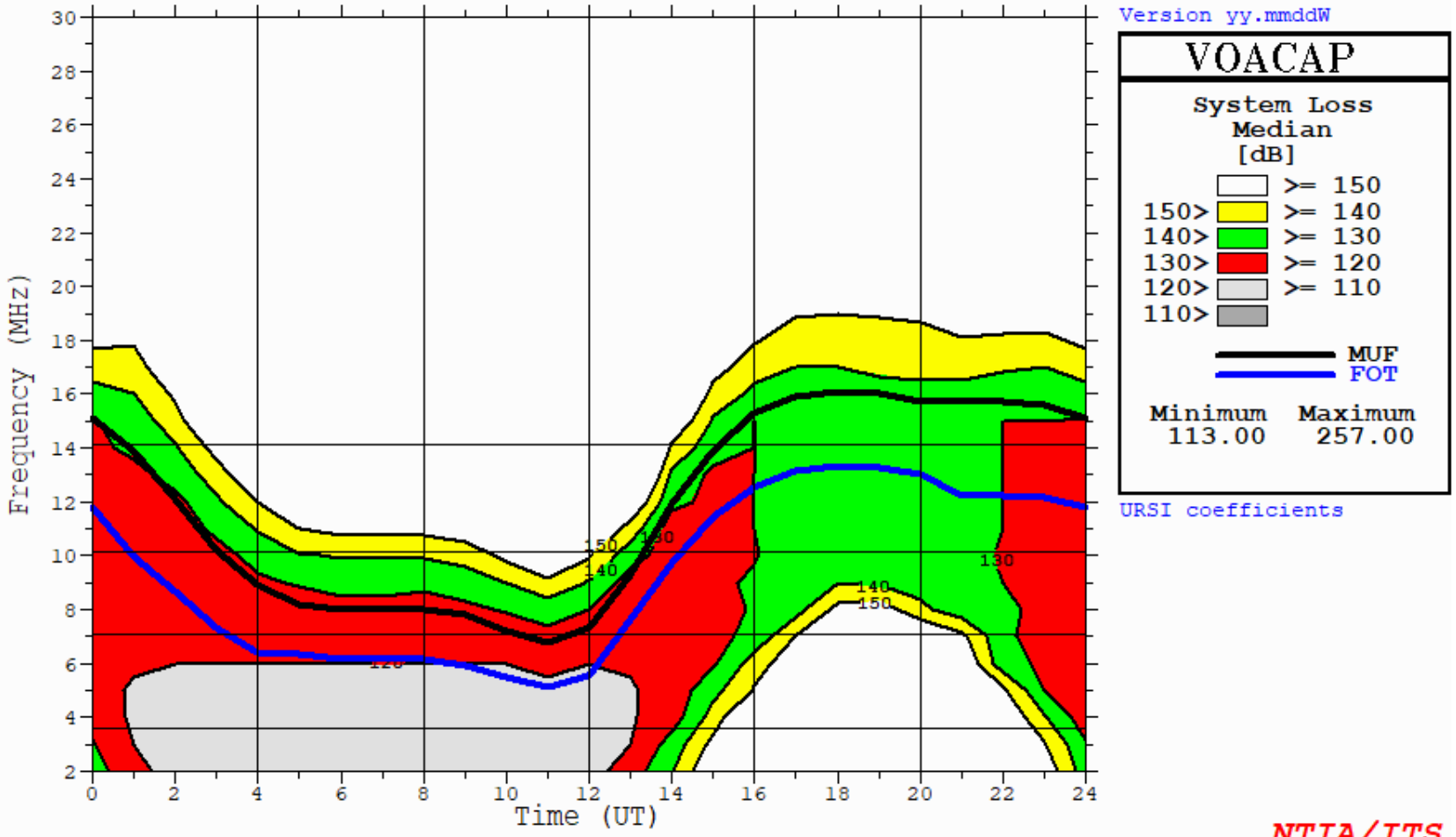
Path Loss defines how much a signal will be attenuated as it propagates from the transmitter to the receiver.

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

LOSS = 130.74 at UT=16.74(16:45) Freq= 14.131 MHz

```
Mar,16 2024          SSN =  86.                Minimum Angle= 0.100 degrees
ALBUQUERQUE         AUSTIN                 AZIMUTHS          N. MI.      KM
35.08 N  106.65 W - 30.30 N   97.75 W    120.08  304.89      533.1     987.2
XMTR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=120.1    0.050kW
RCVR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=304.9
3 MHz NOISE = -145.0 dBW     REQ. REL = 90%    REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms
```



Path Loss Example
Frequency = 14.131 MHz
LOSS = 130.74 dB

Transmit Signal Power Output Level = 100 watts = 50 dBm

Received Signal Power Level = 50 dBm -130.74 dB = -80.74 dBm

-80.74 dBm = 8.43 pico watts

On your S unit Meter, a -80.74 dBm is in between an S7 and S8

Examples of how Amateur Radio Operators use VOACAP

- Contesters
- Worldwide SSB
- DX Expedition Chasers
- Best band to work NE portion of the CONUS
- Best HF band to work East Asia
- Best HF Band to work an Arctic Expedition

KC5RUO used VOACAP to determine the best band to work a Winlink VARA HF Radio Message Server Gateway from a city park with no internet access

What VOACAP **is** and what it **isn't**

- VOACAP is - a **quiet sun signal** path loss vs frequency prediction tool that only uses the current smoothed sunspot number (SSN)
- VOACAP **does not** account for HF propagation disturbances generated by:
  - Geomagnetic Storms: Coronal mass ejections, high-speed solar winds originating from coronal holes
  - Solar Radiation Storms: solar flares that release electromagnetic energy that travel at the speed of light and arrive at Earth in minutes
  - Radio Blackouts: caused by x-ray radiation from solar flares
- HF propagation disturbance predictions from a **disturbed sun** can be derived from https://www.swpc.noaa.gov/, National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center website

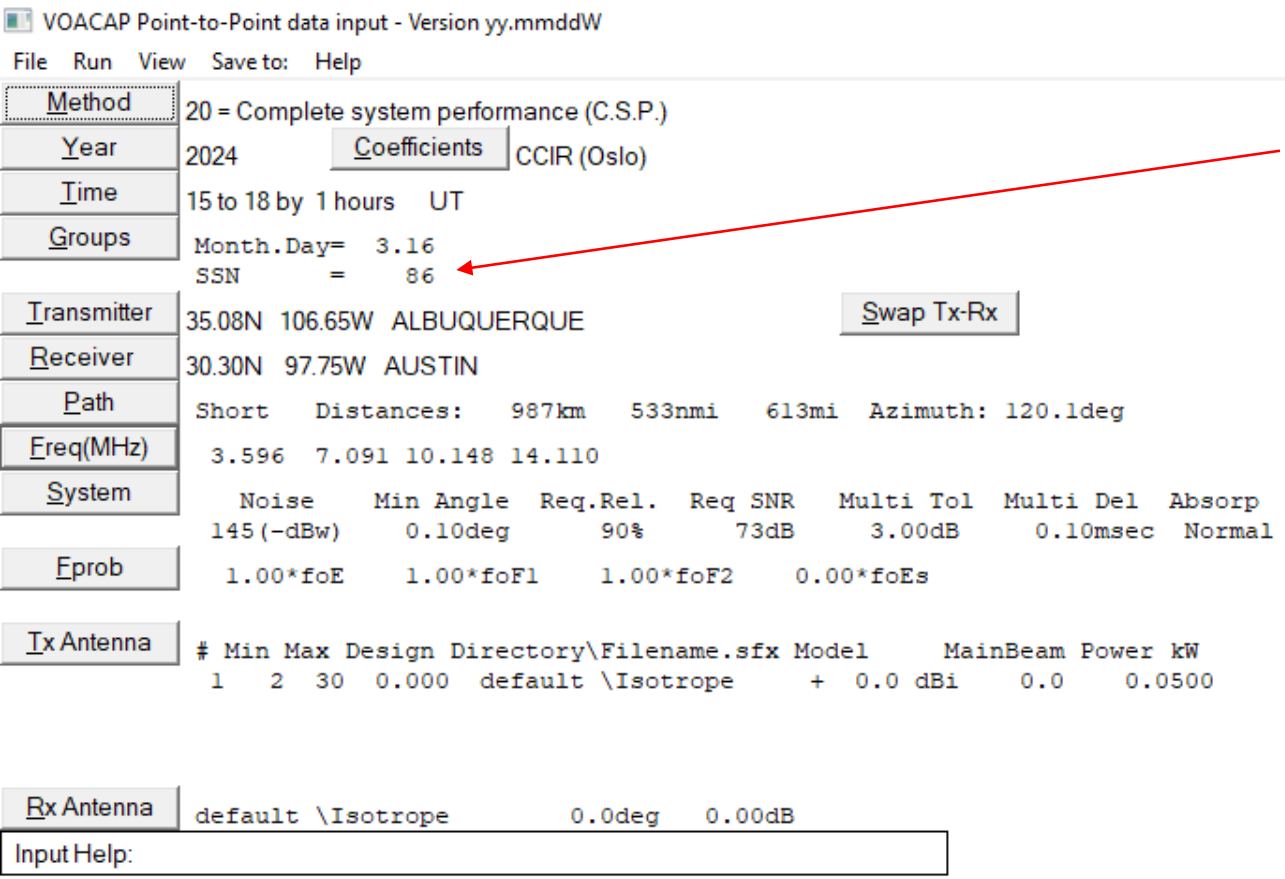
Take away – VOACAP predicts path loss from normal solar activity

- **VOACAP predicts the Maximum Useable Frequency (MUF)**
  - MUF is a function of the:
    - Path Length i.e., Great Earth Circle Distance between the transmitter and the receiver via the F region of the ionosphere
    - Date and time of day (latitude position of the sun)
    - Seasonal position of the sun
    - Solar UV and X-ray radiation levels, derived from the smoothed sunspot number (SSN)
- **VOACAP predicts the path loss for specific frequencies of interest**
- VOACAP also predicts the **Frequency of Optimum Traffic** (FoT)
  - KC5RUO uses the FoT because it is the frequency that gives the highest probability of establishing and sustaining link connectivity between the transmitter and the receiver
  - The FoT is the frequency that provides a 90% probability of successfully working traffic between transmitter and receiver,
    - Whereas, the MUF is the frequency that provides a 50% probability of successfully working traffic between transmitter and receiver.
  - **The FoT = (0.85) x MUF**

My reason for using VOACAP – which band do I use to establish connectivity with N5TW, WA5TED, N0DAJ, and KO0OOO

- N5TW, Georgetown, TX: 20m, 30m, 40m, 80m
- WA5TED, Lubbock, TX: 20m, 30m, 40m
- N0DAJ, Wickenburg, AZ: 20m, 30m, 40m, 80m
- KO0OOO, Las Vegas, NV: 20m, 30m, 40m, 80m

Work through a VOACAP signal path loss prediction calculation



Where do I retrieve the SSN from?

- https://solar.w5mmw.net/ Solar Conditions and Ham Radio Propagtion
- https://www.hfpropagation.com/ Amateur Radio: Usable HF Frequencies
- https://hamradiofornontechies.com/current-ham-radio-conditions/ Current Ham Radio Propagation conditions

VOACAP Point-to-Point data input - Version yy mmddW

File Run View Save to: Help

Method 20 = Complete system

Year 2024 Coeffici

Time 15 to 18 by 1 hours

Groups Month.Day= 3.16
SSN = 86

Transmitter 35.08N 106.65W ALB

Receiver 30.30N 97.75W AUS

Path Short Distance

Freq(MHz) 3.590 7.102 10

System Noise Min
145(-dBw) 0.

Eprob 1.00*foE 1.

Tx Antenna # Min Max Design
1 2 30 0.00

Rx Antenna default \Isotrop

Input Help:

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

Pick (x,y) location for readout

Select PARAMETER to plot from: Group # 1 3.16 86ssn

Exit

Group # 1 3.16 86ssn

Parameter	[Minimum/Maximum]
TANGLE= Radiation angle (degrees)	[6.90/ 37.30]
DELAY = Time delay (milliseconds)	[3.40/ 4.40]
VHITE = Virtual height (km)	[80.00/ 421.00]
MUFday= % of days/month sky-wave propagation expected at MUF	[0.00/ 100.00]
LOSS = Median system loss (dB)	[113.00/ 257.00]
DBU = Median field strength at receive location (dBu)	[-126.00/ 21.00]
SDBW = Median signal power at receiver (dBW)	[-240.00/ -96.00]
NDBW = Median noise power at receiver (dBW)	[-173.00/-130.00]
SNR = Median signal-to-noise ratio (dB)	[-100.00/ 51.00]
RPWRG = Required power & antenna gain to achieve reliab (dB)	[36.00/ 184.00]
REL = Time availability, % time SNR exceeds required SNR	[0.00/ 0.00]
MPROB = Probability additional mode in multipath tolerances	[0.00/ 0.00]
SPRB = Service probability, required reliabilty will be met	[0.00/ 5.00]
SIGLW = Lower decile signal pwr (field strength & loss) (dB)	[5.90/ 25.00]
SIGUP = Upper decile signal pwr (field strength & loss) (dB)	[4.10/ 25.00]
SNRLW = Lower decile SNR increment (dB)	[10.10/ 26.80]
SNRUP = Upper decile SNR increment (dB)	[6.90/ 25.70]
TGAIN = Transmitter Antenna Gain (dB)	[0.00/ 0.00]
RGAIN = Receiver Antenna Gain (dB)	[0.00/ 0.00]
SNRxx = Signal-to-Noise ratio (dB) at Req. Rel.	[-111.00/ 37.00]

Type here to search

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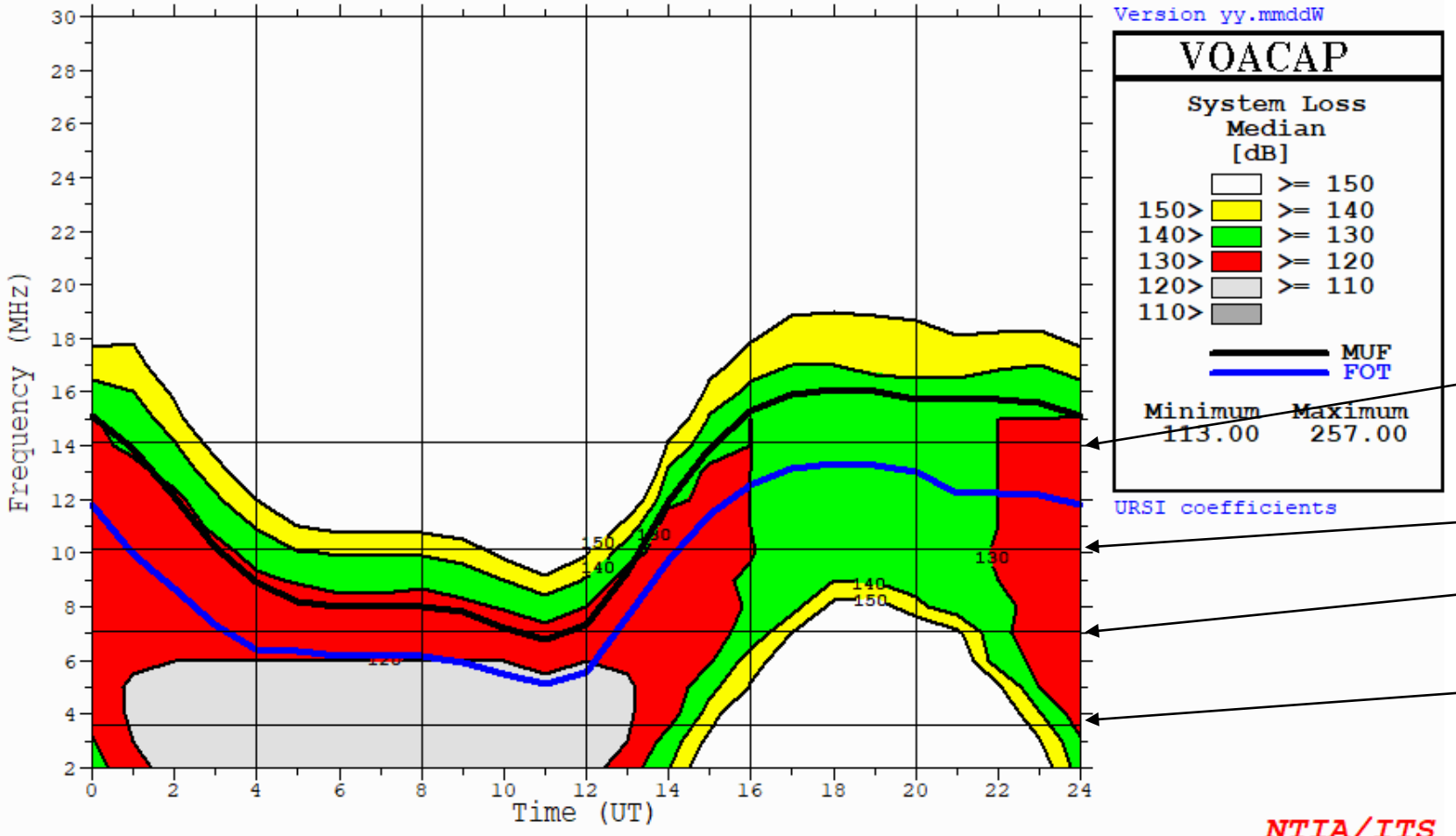
06:11
3/13/2024

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

Pick (x,y) location for readout

```
Mar,16 2024          SSN =  86.                Minimum Angle= 0.100 degrees
ALBUQUERQUE         AUSTIN                  AZIMUTHS          N. MI.      KM
35.08 N  106.65 W - 30.30 N   97.75 W    120.08  304.89      533.1     987.2
XMTR  2-30 +  0.0 dBi[default\Isotrope      ] Az=  0.0 OFFaz=120.1    0.050kW
RCVR  2-30 +  0.0 dBi[default\Isotrope      ] Az=  0.0 OFFaz=304.9
3 MHz NOISE = -145.0 dBW     REQ. REL = 90%    REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms
```



14.110 MHz

10.148 MHz

7.0915 MHz

3.596 MHz

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3/13/2024

VOACAP Point-to-Point data input - Version yy.mmddW

File Run View Save to: Help

Method — 20 = Complete system performance (C.S.P.)

Year — 2024 — Coefficients — CCIR (Oslo)

Time — 15 to 18 by 1 hours UT

Groups

```
Month.Day=  3.16
SSN       =    86
```

Transmitter — 30.30N 97.75W AUSTIN — Swap Tx-Rx

Receiver — 35.08N 106.65W ALBUQUERQUE

Path

```
Short   Distances:   987km   533nmi   613mi  Azimuth: 304.9deg
```

Freq(MHz)

```
 3.596  7.091 10.148 14.110
```

System

```
   Noise     Min Angle  Req.Rel.  Req SNR   Multi Tol  Multi Del  Absorp
 145(-dBw)     0.10deg      90%       73dB     3.00dB     0.10msec  Normal
```

Eprob

```
  1.00*foE    1.00*foF1    1.00*foF2    0.00*foEs
```

Tx Antenna

```
# Min Max Design Directory\Filename.sfx Model     MainBeam Power kW
 1   2  30  0.000  default \Isotrope     +  0.0 dBi    0.0    0.0500
```

Rx Antenna

```
default \Isotrope         0.0deg    0.00dB
```

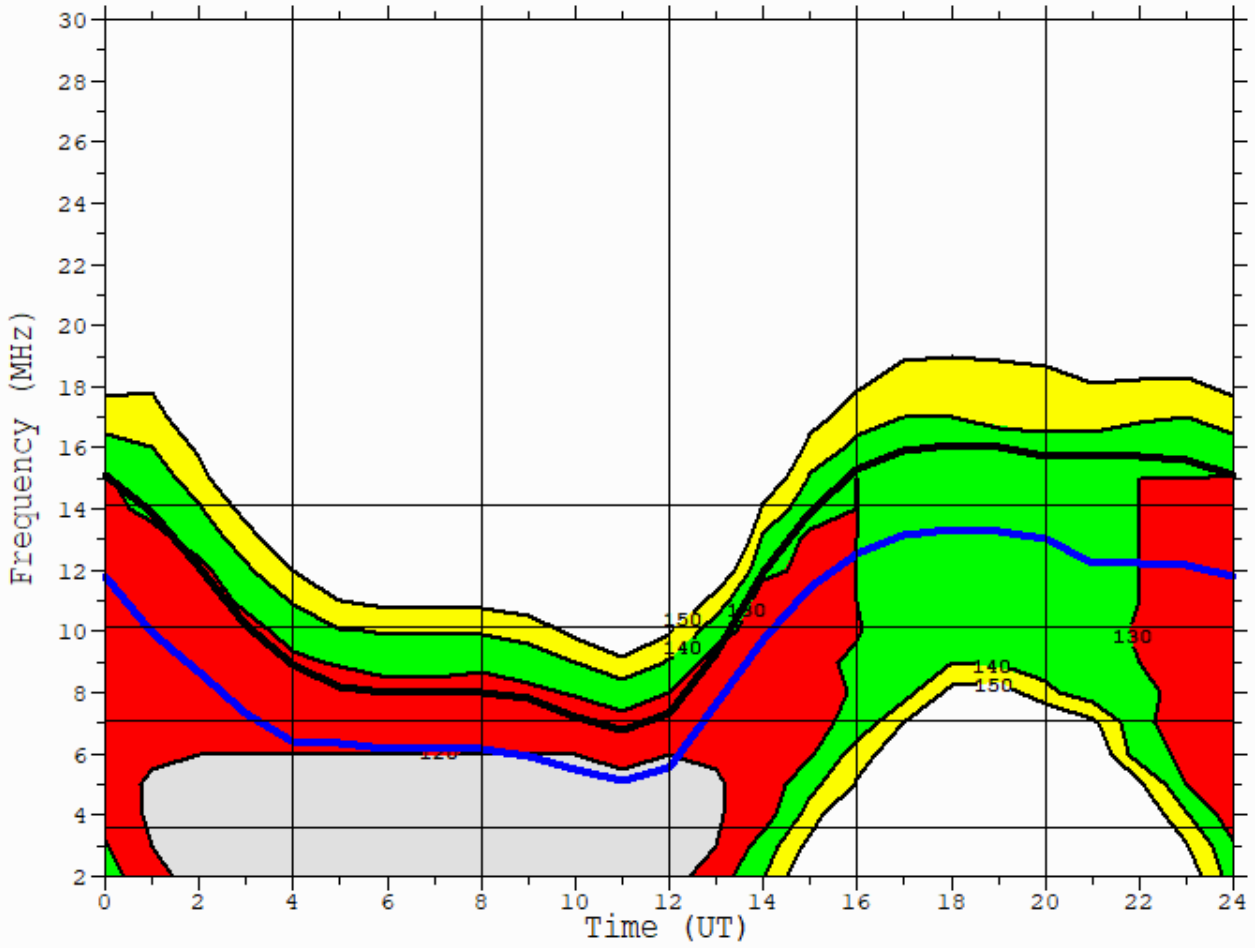
Input Help:

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

Pick (x,y) location for readout

```
Mar,16 2024          SSN =  86.                Minimum Angle= 0.100 degrees
AUSTIN              ALBUQUERQUE          AZIMUTHS          N. MI.      KM
30.30 N   97.75 W - 35.08 N  106.65 W    304.89  120.08     533.1     987.2
XMTR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=304.9    0.050kW
RCVR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=120.1
3 MHz NOISE = -145.0 dBW     REQ. REL = 90%    REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms
```



Version yy.mmddW

VOACAP

System Loss
Median
[dB]

	>= 150
150>	>= 140
140>	>= 130
130>	>= 120
120>	>= 110
110>	

MUF
FOT

Minimum	Maximum
113.00	257.00

URSI coefficients

NTIA/ITS

VOACAP Point-to-Point data input - Version yy.mmddW

File Run View Save to: Help

Method — 20 = Complete system performance (C.S.P.)

Year — 2024 — Coefficients — CCIR (Oslo)

Time — 15 to 18 by 1 hours UT

Groups

```
Month.Day=  3.16
SSN       =    86
```

Transmitter — 35.08N 106.65W ALBUQUERQUE — Swap Tx-Rx

Receiver — 33.57N 101.65W LUBBOCK

Path

```
Short   Distances:   489km   264nmi   304mi  Azimuth: 108.7deg
```

Freq(MHz)

```
 7.104 10.130 14.065
```

System

```
  Noise     Min Angle  Req.Rel.  Req SNR   Multi Tol  Multi Del  Absorp
145(-dBw)     0.10deg      90%       73dB     3.00dB     0.10msec  Normal
```

Fprob

```
 1.00*foE    1.00*foF1    1.00*foF2    0.00*foEs
```

Tx Antenna

```
# Min Max Design Directory\Filename.sfx Model     MainBeam Power kW
 1   2  30  0.000  default \Isotrope     +  0.0 dBi    0.0    0.0500
```

Rx Antenna

```
default \Isotrope         0.0deg    0.00dB
```

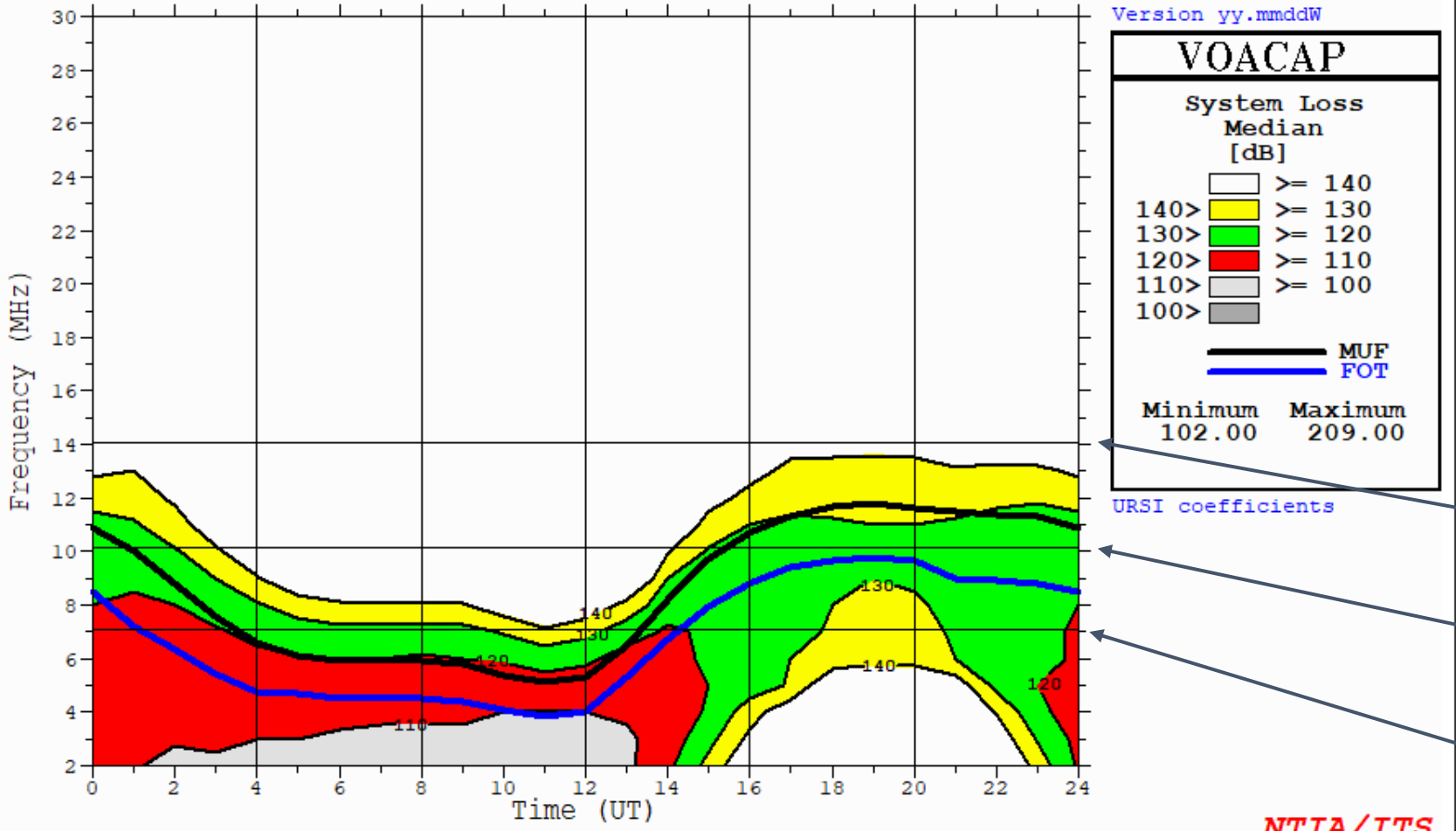
Input Help:

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

Pick (x,y) location for readout

```
Mar,16 2024          SSN =  86.                Minimum Angle= 0.100 degrees
ALBUQUERQUE        LUBBOCK                 AZIMUTHS          N. MI.      KM
35.08 N  106.65 W - 33.57 N  101.65 W    108.66  291.48     263.9     488.7
XMTR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=108.7    0.050kW
RCVR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=291.5
3 MHz NOISE = -145.0 dBW     REQ. REL = 90%    REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms
```



14.065 MHz

10.130 MHz

7.1038 MHz

Type here to search

47°F

06:40

3/13/2024

VOACAP Point-to-Point data input - Version yy.mmddW

File Run View Save to: Help

Method — 20 = Complete system performance (C.S.P.)

Year — 2024 — Coefficients — CCIR (Oslo)

Time — 15 to 18 by 1 hours UT

Groups

```
Month.Day=  3.16
SSN       =    86
```

Transmitter — 35.08N 106.65W ALBUQUERQUE — Swap Tx-Rx

Receiver — 33.97N 112.73W WICKENBURG

Path

```
Short   Distances:   570km   308nmi   354mi  Azimuth: 259.2deg
```

Freq(MHz)

```
 3.590  7.108 10.147 14.115
```

System

```
  Noise     Min Angle  Req.Rel.  Req SNR   Multi Tol  Multi Del  Absorp
145(-dBw)     0.10deg      90%       73dB     3.00dB     0.10msec  Normal
```

Eprob

```
 1.00*foE    1.00*foF1    1.00*foF2    0.00*foEs
```

Tx Antenna

```
# Min Max Design Directory\Filename.sfx Model     MainBeam Power kW
 1   2  30  0.000  default \Isotrope     +  0.0 dBi    0.0    0.0500
```

Rx Antenna

```
default \Isotrope         0.0deg    0.00dB
```

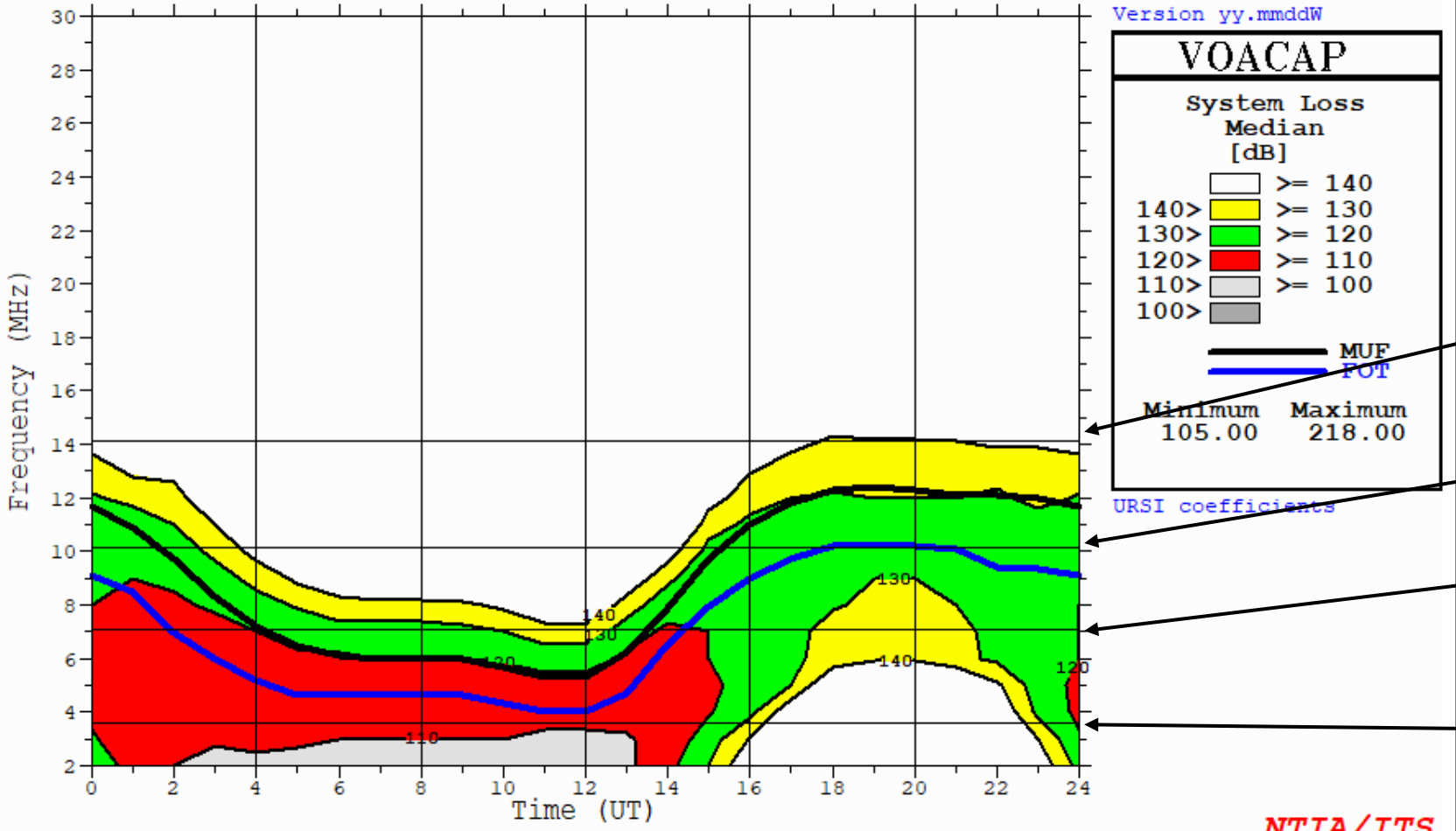
Input Help:

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

LOSS = 127.80 at UT=17.90(17:54) Freq= 10.149 MHz

```
Mar,16 2024          SSN =  86.                Minimum Angle= 0.100 degrees
ALBUQUERQUE        WICKENBURG            AZIMUTHS          N. MI.      KM
35.08 N  106.65 W - 33.97 N  112.73 W    259.24   75.79     308.0     570.3
XMTR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=259.2    0.050kW
RCVR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz= 75.8
3 MHz NOISE = -145.0 dBW     REQ. REL = 90%    REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms
```



14.115 MHz

10.147 MHz

7.108 MHz

3.590 MHz

Type here to search

47°F

08:42

3/13/2024

VOACAP Point-to-Point data input - Version yy.mmdd

File Run View Save to: Help

Method — 20 = Complete system performance (C.S.P.)

Year — 2024 — Coefficients — CCIR (Oslo)

Time — 15 to 18 by 1 hours UT

Groups

```
Month.Day=  3.16
SSN       =    56
```

Transmitter — 35.08N 106.65W ALBUQUERQUE — Swap Tx-Rx

Receiver — 36.17N 115.15W LAS VEGAS

Path

```
Short   Distances:   777km   420nmi   483mi  Azimuth: 281.4deg
```

Freq(MHz)

```
 3.590  7.102 10.142 14.110
```

System

```
   Noise     Min Angle  Req.Rel.  Req SNR   Multi Tol  Multi Del  Absorp
 145(-dBw)     0.10deg      90%       73dB     3.00dB     0.10msec  Normal
```

Eprob

```
  1.00*foE    1.00*foF1    1.00*foF2    0.00*foEs
```

Tx Antenna

```
# Min Max Design Directory\Filename.sfx Model     MainBeam Power kW
 1   2  30  0.000  default \Isotrope     +  0.0 dBi    0.0    0.0500
```

Rx Antenna

```
default \Isotrope         0.0deg    0.00dB
```

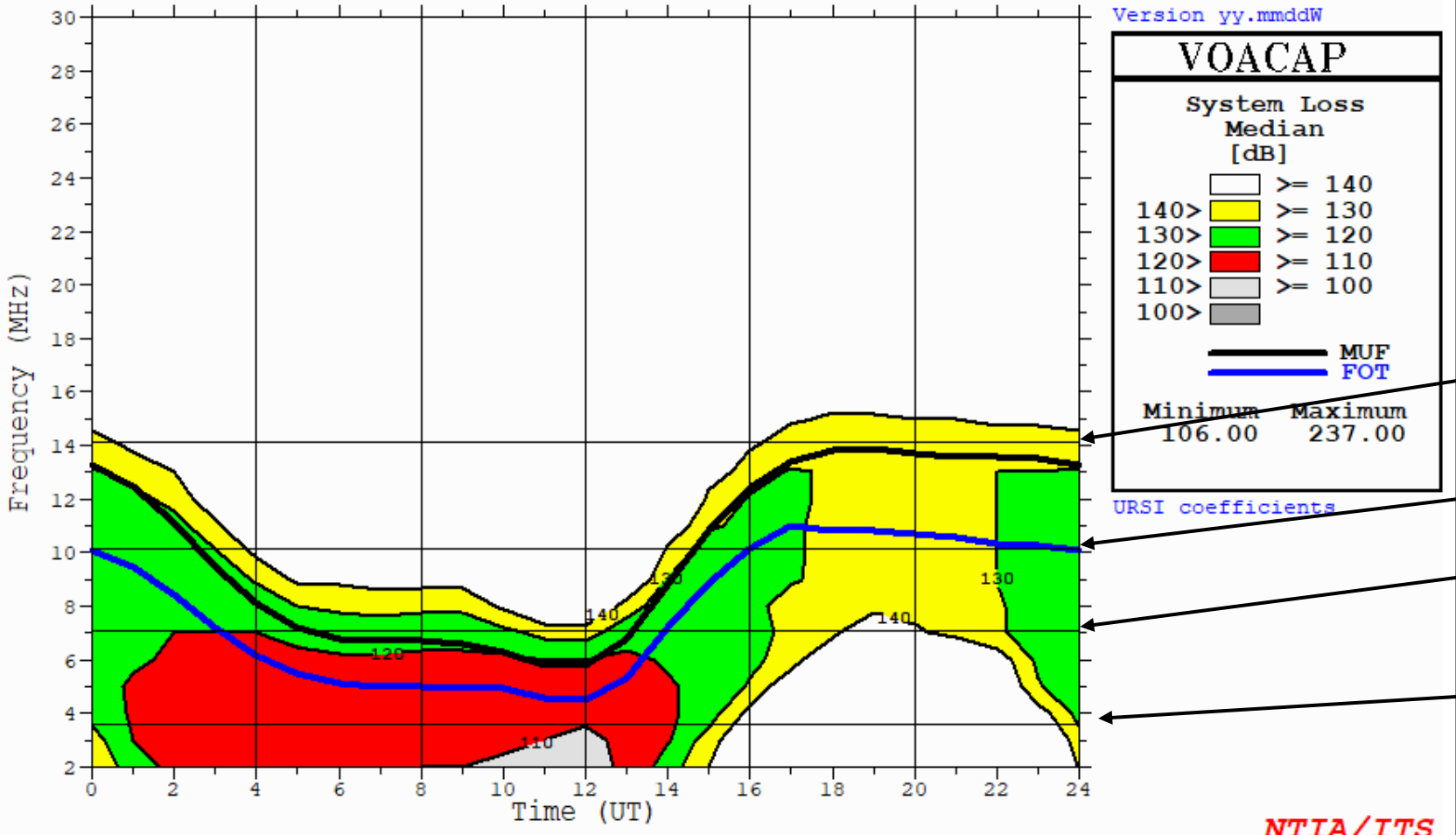
Input Help:

Perform plot for file:VOACAPg.out

Exit Print to Clipboard Parameters User lines Color Scale Help

LOSS = 127.14 at UT=15.99(15:59) Freq= 10.149 MHz

```
Mar,16 2024          SSN =  86.                Minimum Angle= 0.100 degrees
ALBUQUERQUE        LAS VEGAS              AZIMUTHS          N. MI.      KM
35.08 N  106.65 W - 36.17 N  115.15 W    281.43   96.47     419.8     777.4
XMTR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz=281.4    0.050kW
RCVR  2-30 +  0.0 dBi[default\Isotrope     ] Az=  0.0 OFFaz= 96.5
3 MHz NOISE = -145.0 dBW     REQ. REL = 90%    REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms
```



14.110 MHz

10.142 MHz

7.102 MHz

3.589 MHz

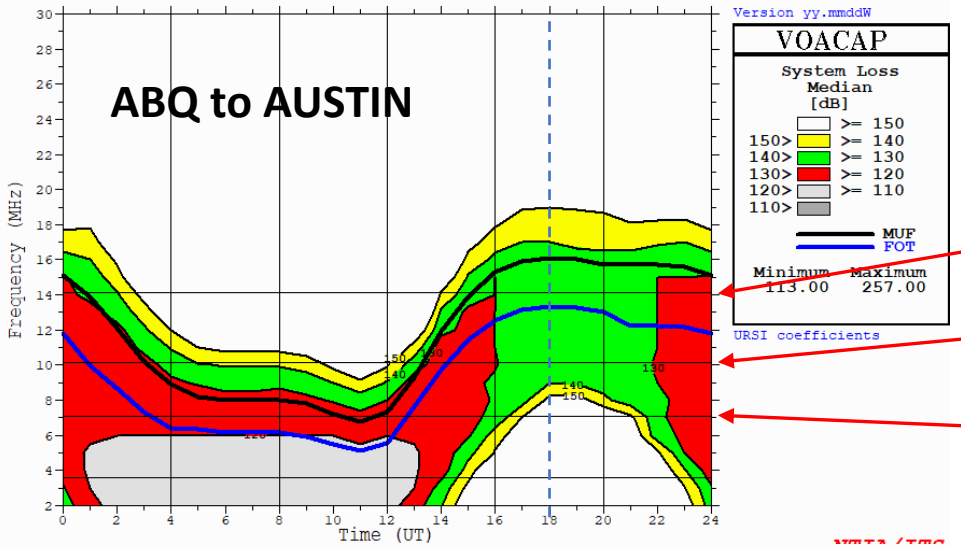
Type here to search

47°F

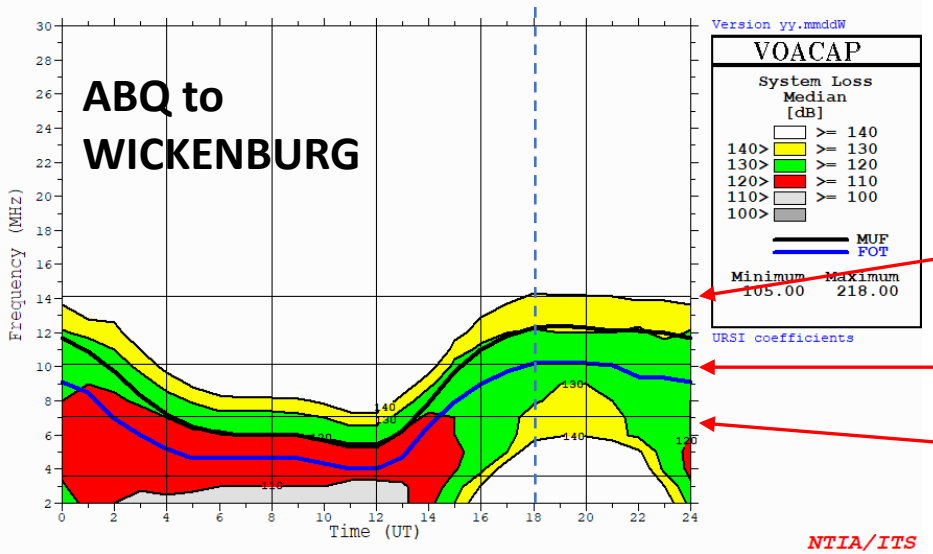
08:56

3/13/2024

Mar,16 2024 SSN = 86. Minimum Angle= 0.100 degrees
ALBUQUERQUE AUSTIN AZIMUTHS N. MI. KM
35.08 N 106.65 W - 30.30 N 97.75 W 120.08 304.89 533.1 987.2
XMTR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz=120.1 0.050kW
RCVR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz=304.9
3 MHz NOISE = -145.0 dBW REQ. REL = 90% REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE = 3.0 dB MULTIPATH DELAY TOLERANCE = 0.100 ms



Mar,16 2024 SSN = 86. Minimum Angle= 0.100 degrees
ALBUQUERQUE WICKENBURG AZIMUTHS N. MI. KM
35.08 N 106.65 W - 33.97 N 112.73 W 259.24 75.79 308.0 570.3
XMTR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz=259.2 0.050kW
RCVR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz= 75.8
3 MHz NOISE = -145.0 dBW REQ. REL = 90% REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE = 3.0 dB MULTIPATH DELAY TOLERANCE = 0.100 ms

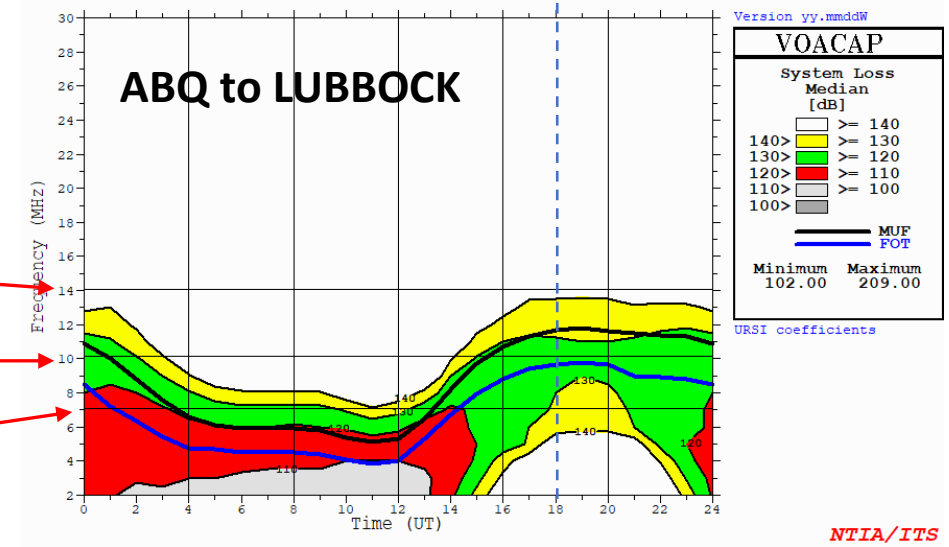


20 M

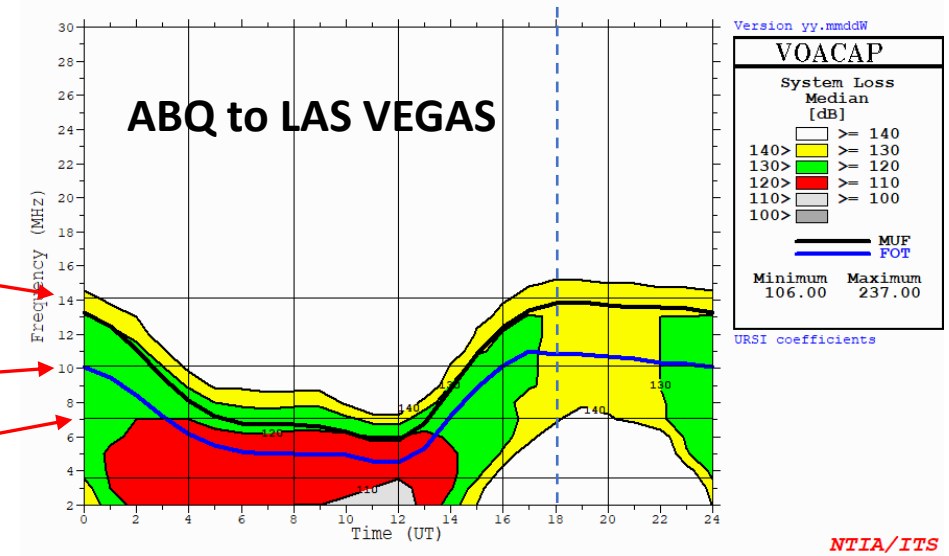
30 M

40 M

Mar,16 2024 SSN = 86. Minimum Angle= 0.100 degrees
ALBUQUERQUE LUBBOCK AZIMUTHS N. MI. KM
35.08 N 106.65 W - 33.57 N 101.65 W 108.66 291.48 263.9 488.7
XMTR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz=108.7 0.050kW
RCVR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz=291.5
3 MHz NOISE = -145.0 dBW REQ. REL = 90% REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE = 3.0 dB MULTIPATH DELAY TOLERANCE = 0.100 ms



Mar,16 2024 SSN = 86. Minimum Angle= 0.100 degrees
ALBUQUERQUE LAS VEGAS AZIMUTHS N. MI. KM
35.08 N 106.65 W - 36.17 N 115.15 W 281.43 96.47 419.8 777.4
XMTR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz=281.4 0.050kW
RCVR 2-30 + 0.0 dBi[default\Isotrope] Az= 0.0 OFFaz= 96.5
3 MHz NOISE = -145.0 dBW REQ. REL = 90% REQ. SNR = 73.0 dB
MULTIPATH POWER TOLERANCE = 3.0 dB MULTIPATH DELAY TOLERANCE = 0.100 ms



Overall, the 30 meter frequencies are closest to FoT

KC5RUO would configure his raised vertical Buddipole Antenna for 30 meters

- Austin: 10.148 MHz
- Lubbock: 10.130 MHz
- Wickenburg: 10.147 MHz
- Las Vegas: 10.142 MHz

Buddipole Antenna tuned to the average of the 4 – 30 meter frequencies

- 10.14175 MHz

Take Aways

- VOACAP predicts signal path loss from normal solar activity
- VOACAP displays the best frequencies to use as a function of time of day
- Use the frequencies/band closest to the FoT

Questions and Comments