HF Propagation

K0NA
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HF Propagation

- You don’t need to know anything about propagation to enjoy ham radio
  - We are typically happy to just talk to some one
- It becomes important when you are starting to chase awards, entering contest, or just have a friend you want to talk to
  - WAS, WAC, DXCC, Field Day, Sweep Stakes, CQWW
- There are no guaranties you will get the station
  - The purpose of this talk is to improve your chances of success and understand how signals get from A to B

Topics

- Focus will be on 20 meters
- Look at launching the wave
- Ionosphere basics
- Critical frequency, MUF, and solar indices
- Propagation prediction methods
- Gray line
- Practical examples

Launching the Wave

- Transmitter to the feed line
- Feed line to the antenna
  - If there is a mismatch there will be a reflected wave
  - The feed line has a velocity factor of less than the speed of light
- The antenna to free space
  - Free space has an impedance of 377 ohms
  - Any mismatch will cause a reflection as in our feed line

The F2 Layer

- Most of the long distance communications takes place in this layer
- There is almost no air in the in the F2 layer
  - One author said if you would bring all the air down from the F2 layer it would be the size of a basket ball
- Some of the atoms in the layer are ionized with UV and Xray waves from the sun to create free electrons
- These electrons move when hit with and electric or magnetic field
  - Moving electrons radiate a signal

Critical Frequency

- The critical frequency is the highest frequency that can be reflected off the ionosphere from a vertically transmitted pulse
  - Above the critical frequency the electrons are too far apart and pass right through the layer
- Because atoms are so far apart the many electrons remain free all night

NEW Proplab-Pro Version 3.0

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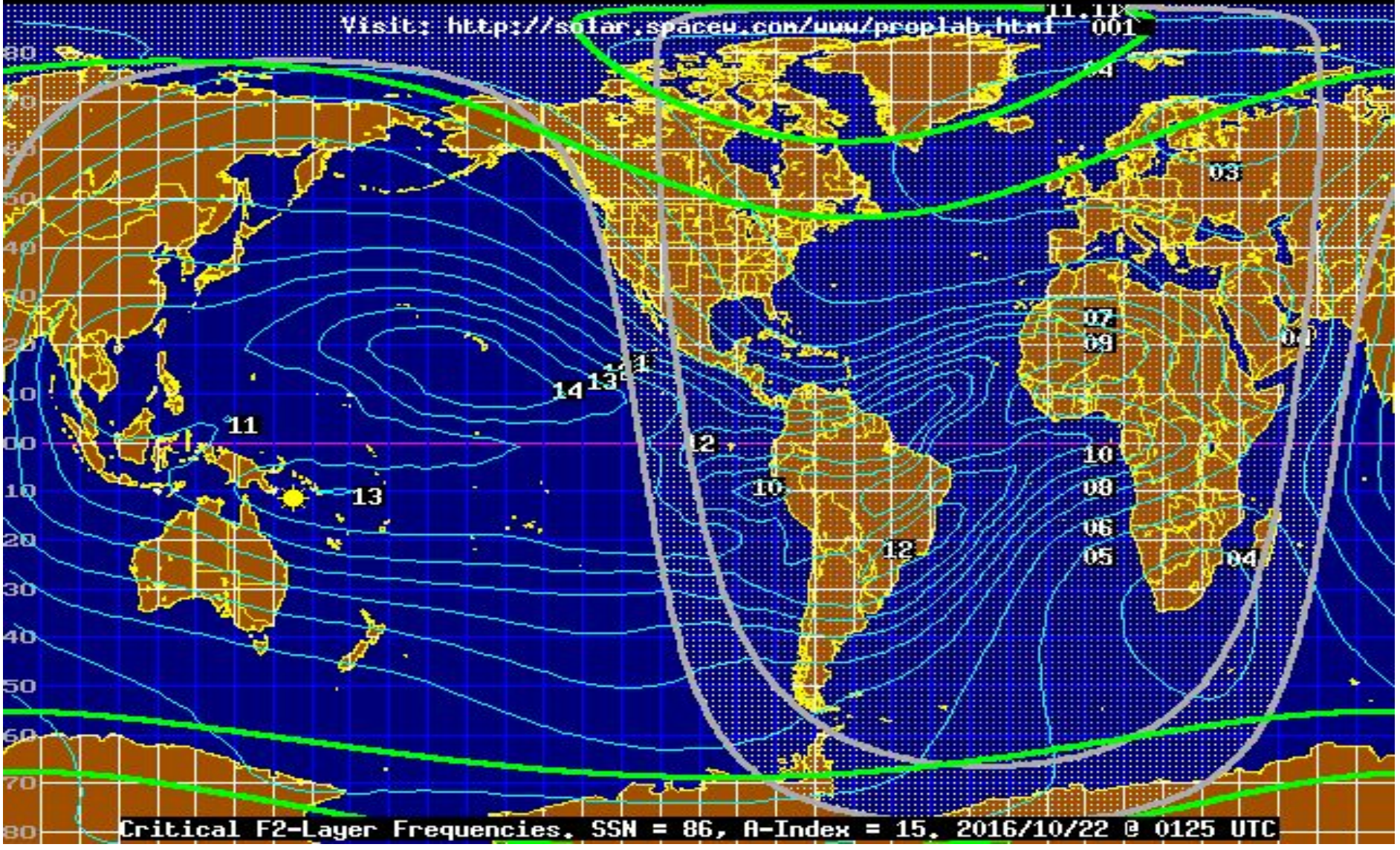
Full Windows compatibility and more horse-power under the hood than you can imagine!



Other Layers

- F1 layer
  - Similar to the F2 layer
  - Lower elevation
  - After sunset most electrons find atoms to join up with at lower elevations
    - The layer merges with the F2 layer
    - During this process the ionosphere tilts
- E layer
  - Quickly disappears after sunset
- D layer
  - A highly absorptive layer that is a real problem in the daytime for lower frequencies

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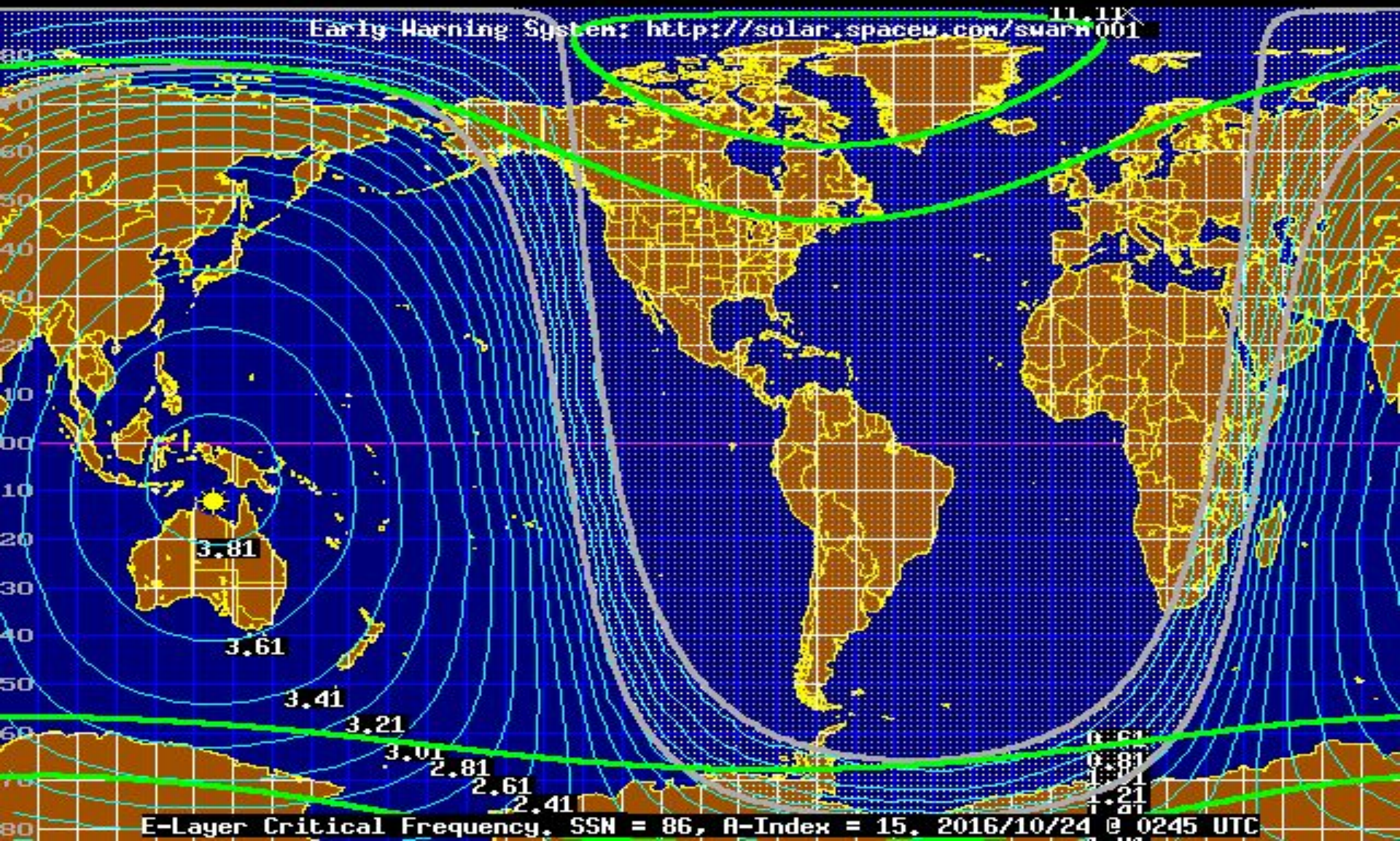


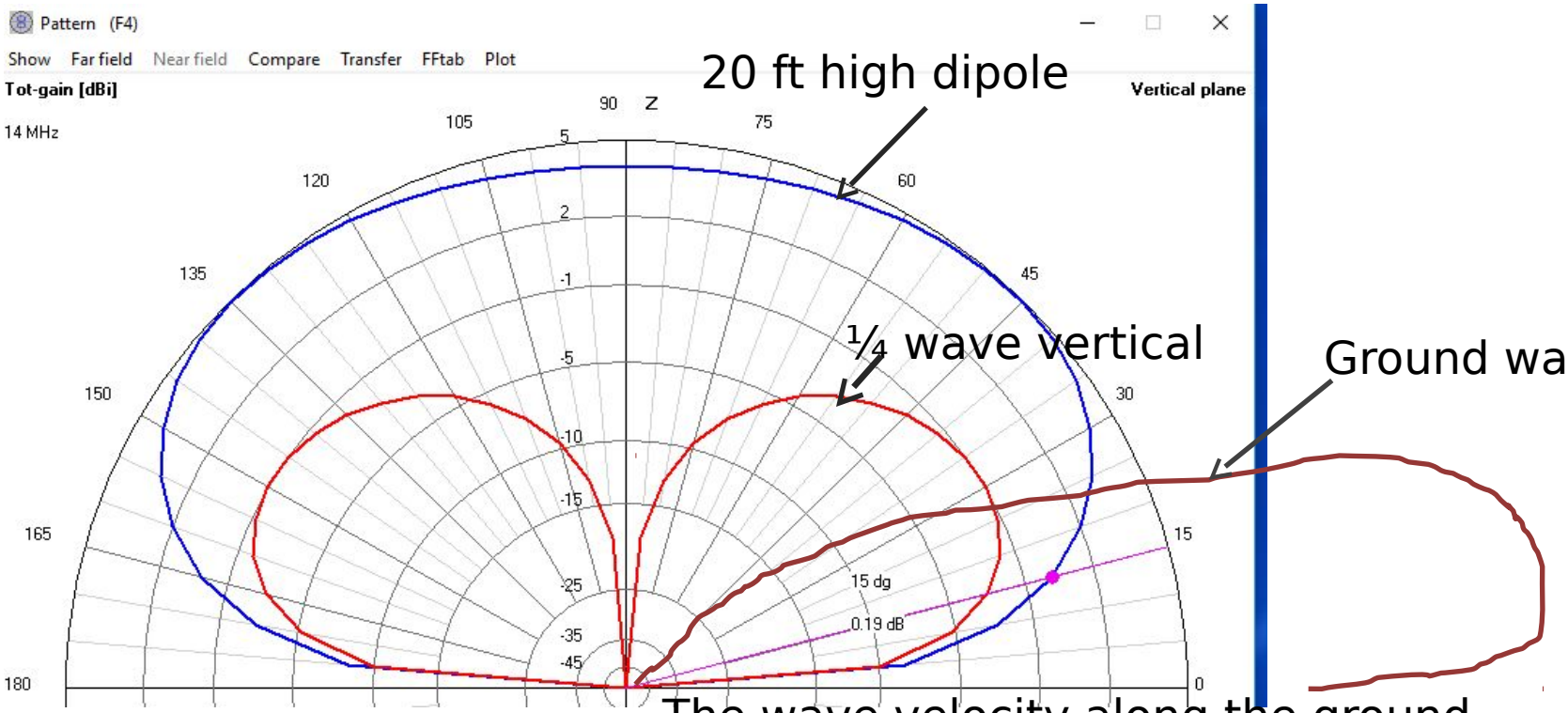
Angle of Radiation

- How far you will get is a function of the angle of the transmitted signal
- Approximate distances vs the angle of radiation for the upper F2 layer
  - Angle Distance
  - 25 degrees 1,000 miles
  - 20 1,600
  - 15 1,800
  - 10 2,200
  - 5 3,000
- The point of reflection is about half the skip distance

Height of the Antenna

- The height of the antenna affects the angle of the signal
- On 20 Meters
  - Height 20 degrees 10 degrees Dbi peak
  - 20 feet 2.0 Dbi -2.7 Dbi 45 degrees
  - 40 4.2 .5 30
  - 60 4.4 2.2 20
  - 100 3.8 6.0 10
  - Vertical -1.7 -5.2 35

Comparing a 20 ft high dipole to a ¼ wave vertical

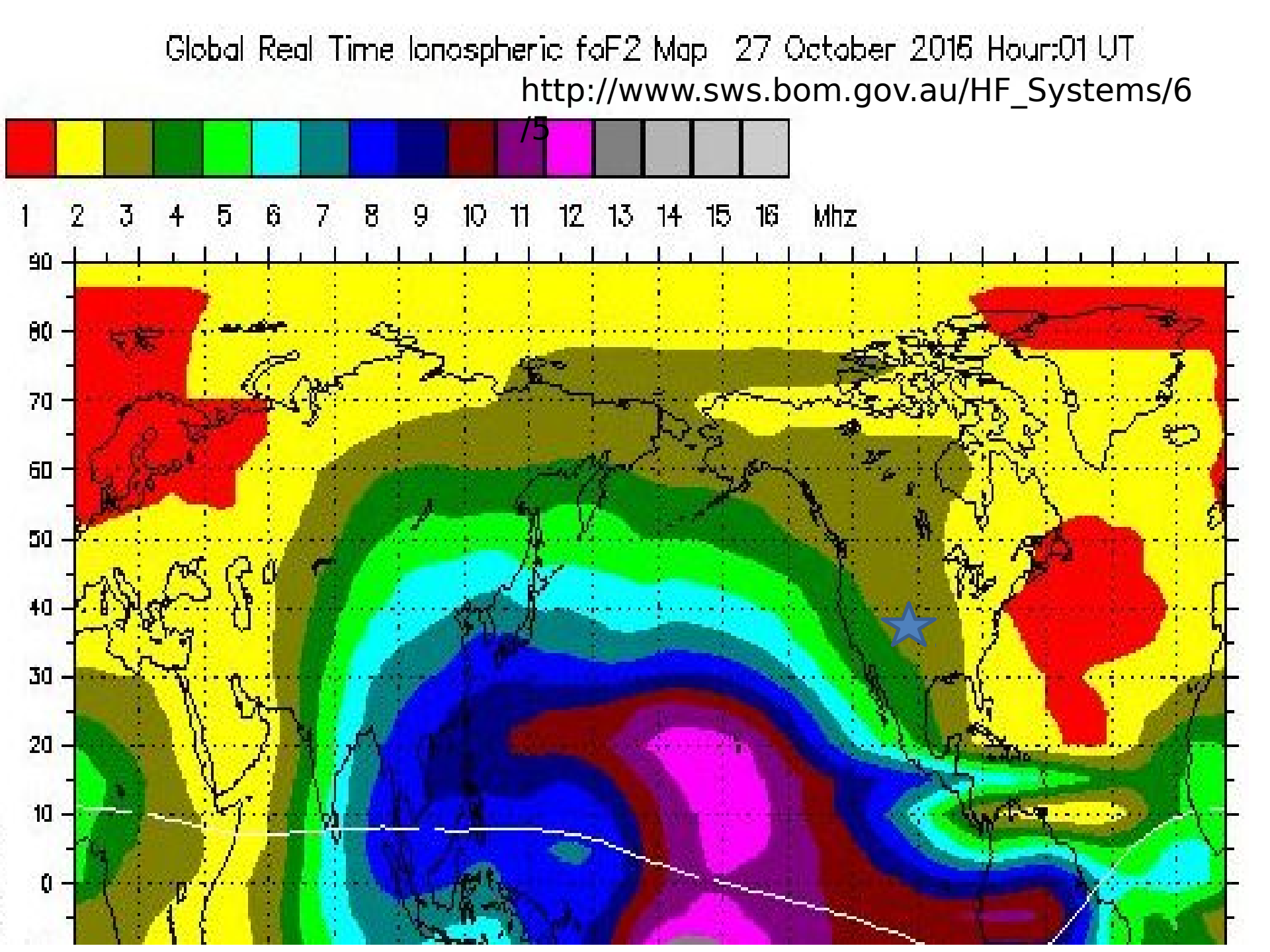


The wave velocity along the ground is 50 to 90% the speed of light and follows the curvature of the earth.

The ground wave separates from the sky wave

Maximum Useable Frequency

- The Maximum Useable Frequency (MUF) is the highest frequency that can be reflected at an angle
- The best signal is typically 10% below the MUF
- MUF=Fo (critical frequency) / sin(radiation angle)
  - 20 degrees MUF=2.92*Fo
  - 10 degrees MUF=5.75*Fo
  - 1 degree MUF=57.3*Fo (not realistic!)


Global Real Time Ionospheric foF2 Map 27 October 2016 Hour:01 UT
http://www.sws.bom.gov.au/HF_Systems/6/5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 Mhz
90
80
70
60
50
40
30
20
10
0

MUF at Various Angles

- 10/27/16, SF=78, SSN=17, A=46, K=5
- 7PM local
- MUF for the 1st skip
  - Direction Fo 20 deg 10 deg
  - N 3.5 MHz 10.2 MHz 20.1 MHz
  - E 3 8.7 17.3
  - S 4.5 13.1

MUF at Various Angles

- 10/27/16 SF=78 SSN=17 A=46 K=5
- 7 PM local
- MUF for the 2nd skip
  - Direction Fo 20 deg 10 deg
  - N 3.1 MHz 9.1 MHz 17.9 MHz
  - E 1.8 5.2 10.4
  - S 5.8 16.9

Solar Indices

- Sun spot number
  - Has been measured for centuries
  - Good correlation to the critical frequency
  - The one I like
- Solar flux
  - Measured at 2800 MHz
  - Non ionizing wave length
  - Reasonable correlation to the sunspot number

Geomagnetic Activity

- The K and A indexes are a measure of changes in the earths magnetic field
  - This greatly affects the polar paths
- K index
  - Measured every 3 hours
  - A logarithmic scale
  - 0 to 2 is good, 3 to 4 is marginal, 5 up is poor
  - Paths to east, south and west are not greatly affected
- A index
  - Calculated from the last 24 hours
  - Like yesterdays weather

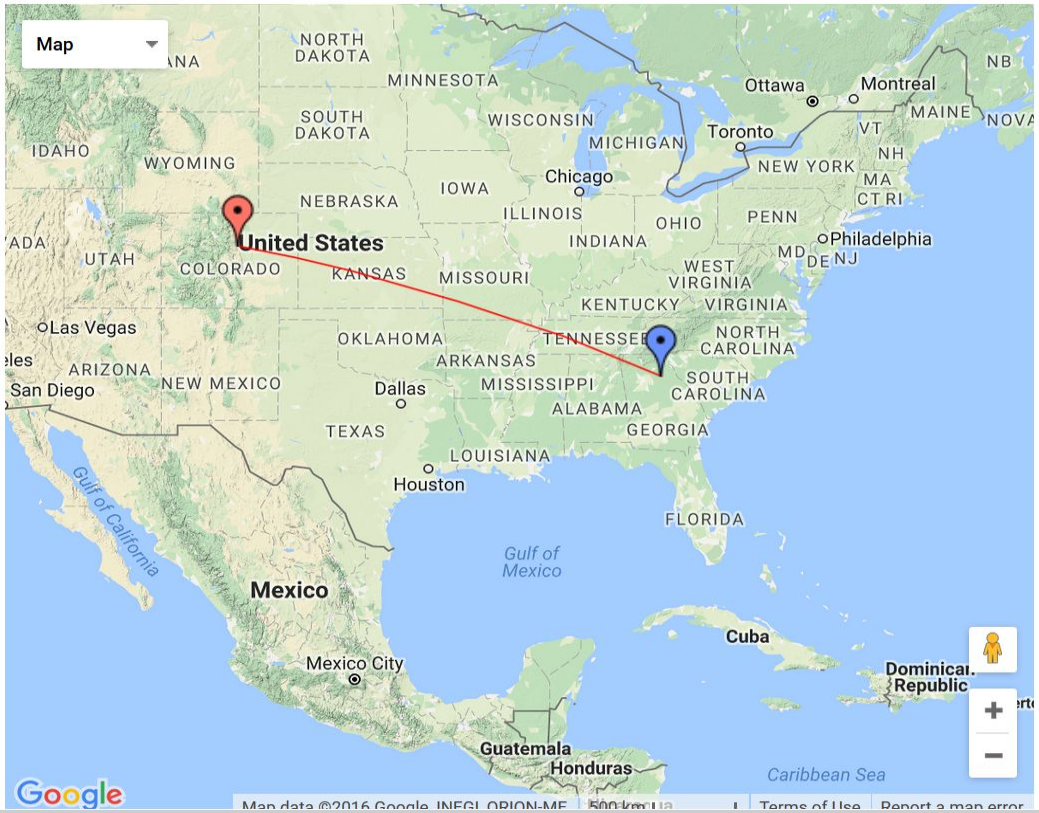
VOACAP

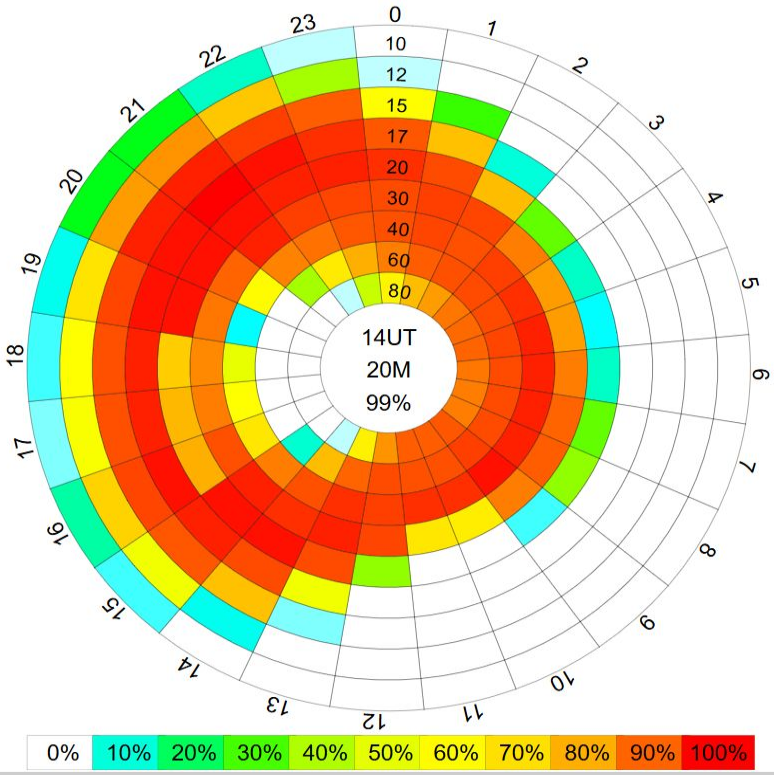
- Voice of America Circuit Analyses Program
  - Free open source
  - Is used as the engine in many aftermarket programs
  - One of the best programs out there
  - Does not use the K index
- Online.voa.com
  - Extremely easy to use

VOACAP Online - professional...

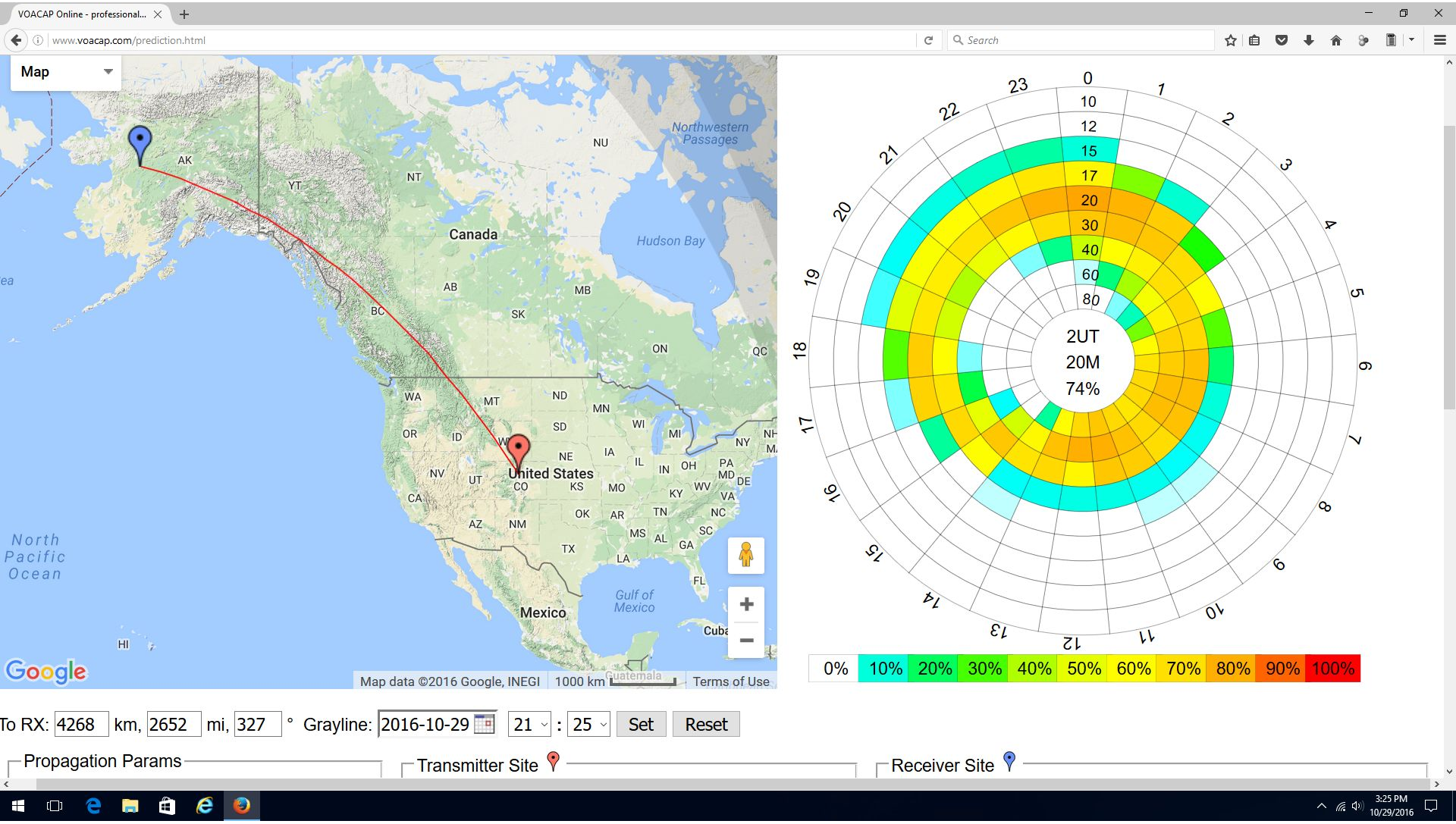
www.voacap.com/prediction.html

VOACAP Online





1:22 PM
10/27/2016


VOACAP Online - professional...
www.voacap.com/prediction.html
Search
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1000 km
Terms of Use
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10%
20%
30%
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50%
60%
70%
80%
90%
100%
To RX: 4268 km, 2652 mi, 327 ° Grayline: 2016-10-29 21 : 25 Set Reset
Propagation Params
Transmitter Site
Receiver Site
3:25 PM
10/29/2016

VOACAP Accurate?

- Testing VOACAP against a RTTY station from Germany at 10.1 MHz
  - A 10KW station broadcasting 24 hours a day
  - A good indication of the path to Europe on 30 M
- Predicted and measured signal strength
  - Time predicted measured
  - 0000 utc S3 S4
  - 0100 S4 S5/6
  - 0230 S5/6 S5/6
  - 1200 S1 S0 (below the noise)
  - 1530 S1 S2 (in the Noise)
  - 1930 S1 S2 “ “ “
  - 2230 S4 S3

```
Jun     2016          SSN =  36.              Minimum Angle= 0.100 degrees
  JO43rl               dm79xs                AZIMUTHS          N. MI.      KM
  53.47 N    9.46 E - 39.77 N  104.04 W    311.66   35.35    4240.6   7852.9
  XMTR  2-30 2-D P-to-P[voaant/v58.ant       ] Az=  0.0 OFFaz=311.7   1.200kW
  RCVR  2-30 2-D P-to-P[voaant/3el15m.ant    ] Az=  0.0 OFFaz= 35.3
  3 MHz NOISE = -155.0 dBW     REQ. REL = 90%    REQ. SNR = 24.0 dB
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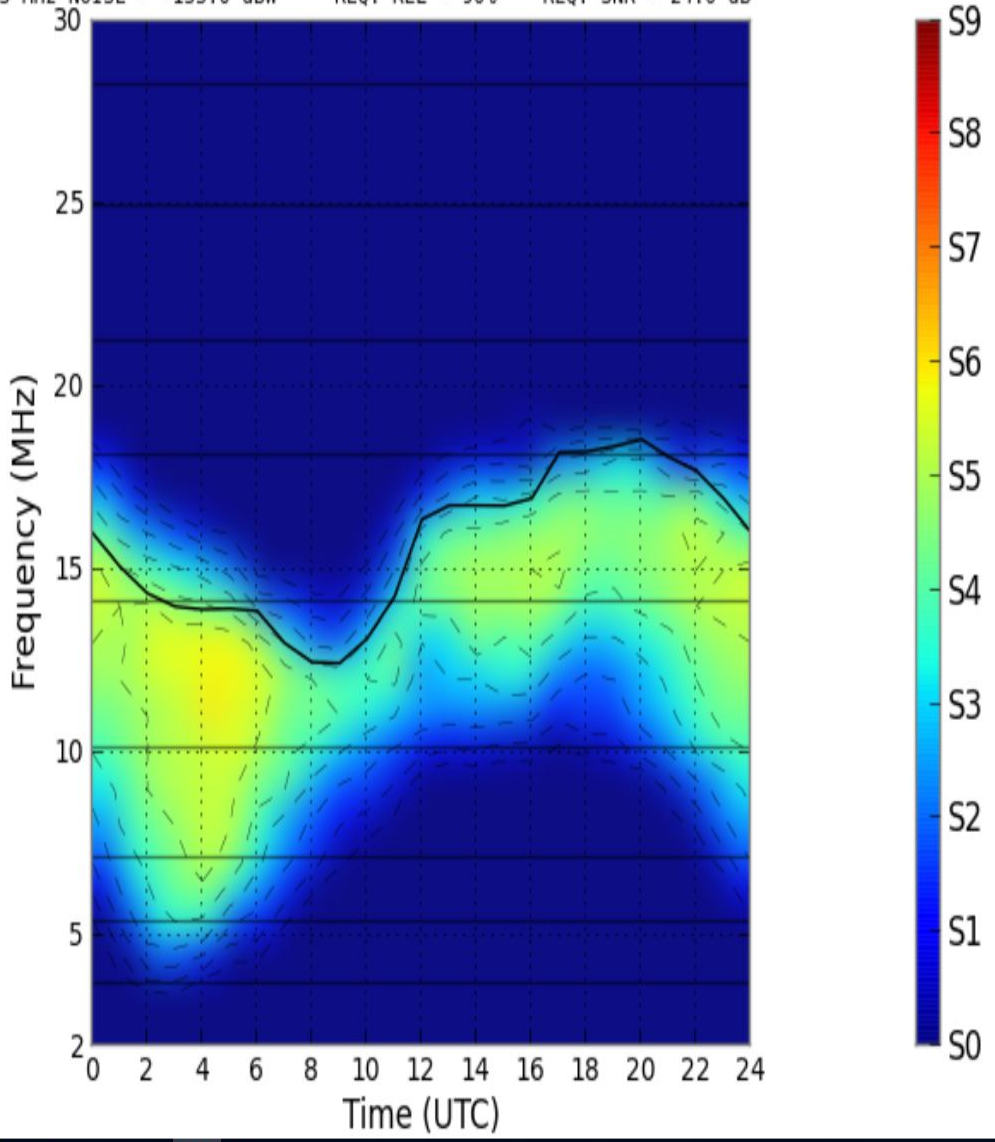

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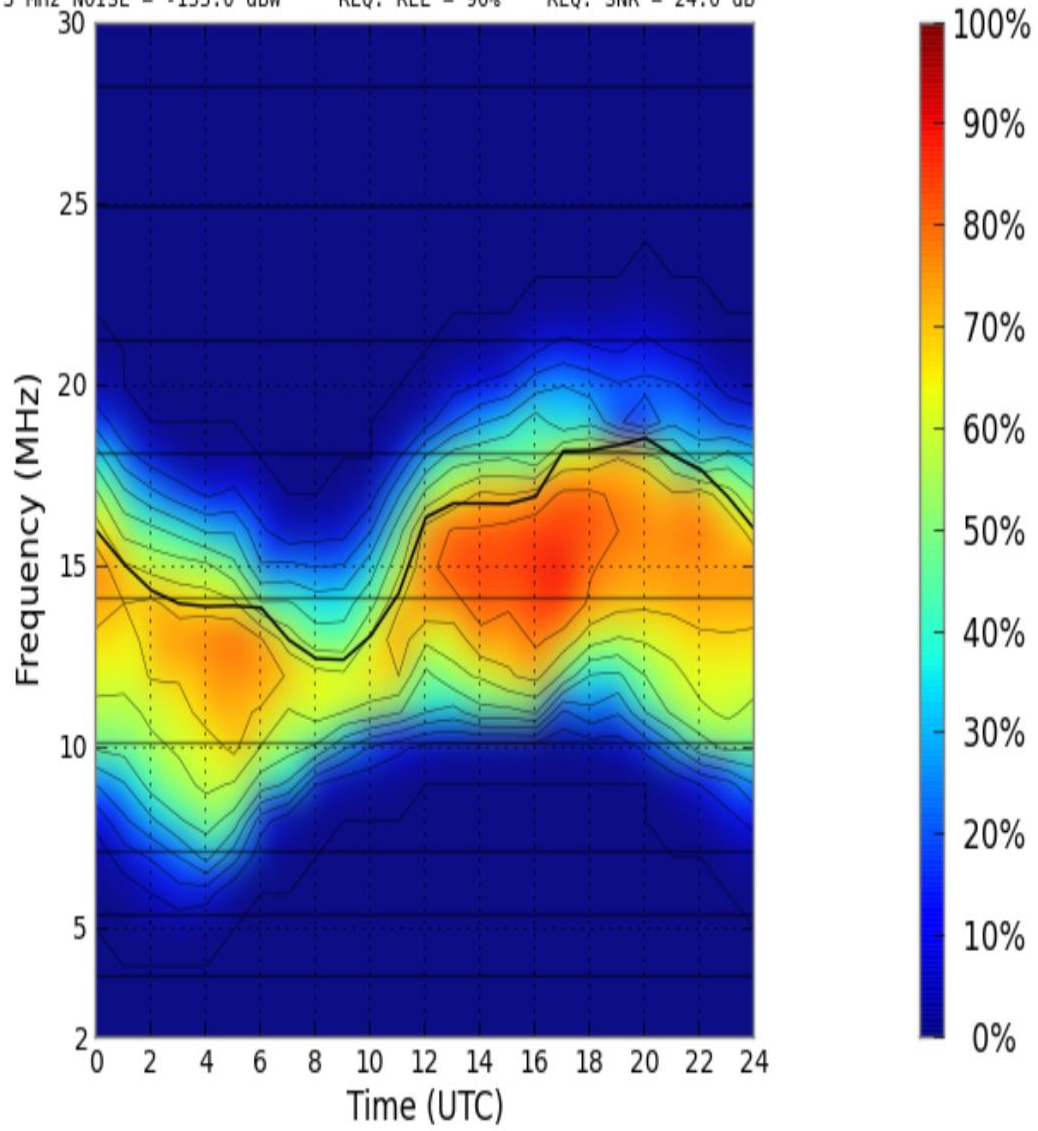
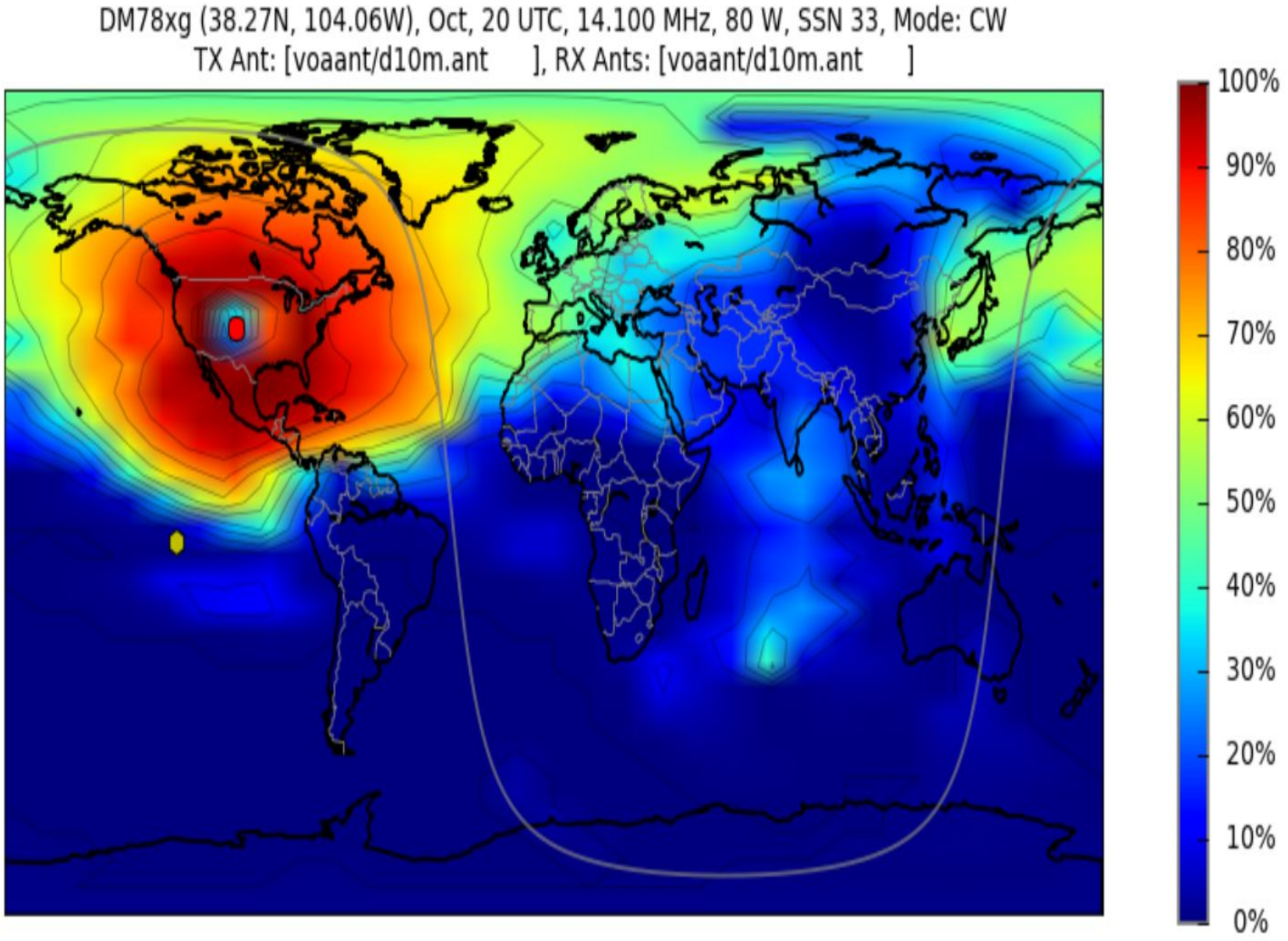


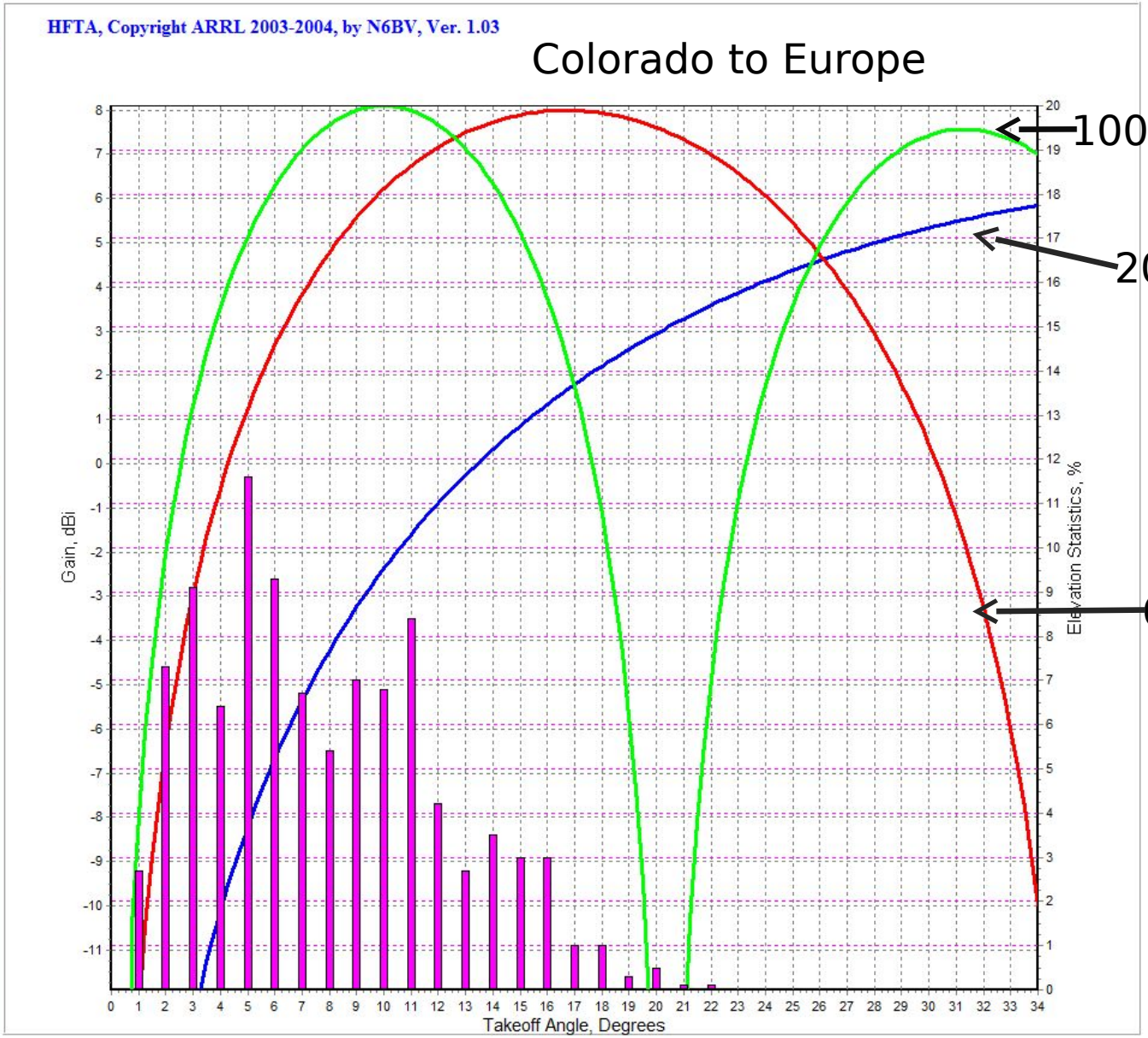
This graph shows the probability of achieving the chosen grade of service (TX mode).



Can I work Europe on 20 M With my 20 Ft High Dipole?

- My antenna is only 20 ft high
  - Most of my signal is going strait up
- What angle will get me into Europe
  - The optimum is 1 to 10 degrees
- If I put up a tower, how much would it help
  - High frequency terrain can answer the question on the next slide
- Yes
  - Your signal will be about 10 DB lower than if you had a 60 ft high dipole

Output Graph, HFTA



Freq. = 14.2 MHz
Max. Gain: 8.1 dBi

FLAT.PRO
20 ft
Dipole
Fig. of Merit: -3.5

FLAT.PRO
60 ft
Dipole
Fig. of Merit: 4.5

FLAT.PRO
100 ft
Dipole
Fig. of Merit: 5.9

Elev. Statistic
W0-CO-EU.PRN

Print | Out File

Close

Securi... Windows Guide

1:46 PM
10/26/2016

How Come the East Coast Can Work Europe so Easy?

- It is because of the number of hops from here
  - Each hop one loses about 6 Db per hop
    - More over land and less over sault water
- The east coast has one less hop to get into Europe
  - They have a 1 to 2 S unit advantage over us
  - Our best chance is when the band goes long and MUF drops for them

Gray Line the Great Equalizer

- At the transition from day to night the ionosphere tilts
  - The tilting ionosphere acts as a huge bill board reflector taking high angle radiation to low angles
- The effect is most obvious on the low bands
  - On 80 M, I see a 1 to 2 S unit peak
  - The effect is less as one goes up in frequency
  - The effect seems to be the strongest at right angles to the gray line
  - There are 2 peaks, one for you, and one for the other station
- The gray line eliminates a lot of the competition from other areas

Tips to Improve Your Chances

- Pay attention to sunrise and sunset times
- Monitor the dx spotting nets
- Monitor who the needed station is working
- Use VOACAP to see how probable you can work the station
- Monitor the beacons
  - 10 M beacons
  - 20 M beacons on 14.1
  - 10.1 RTTY station
- Get on the air!

Questions?