# Near Vertical Incidence Skywave Propagation with *ARES* in Mind

Presented 2020 July 7 by
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Source: Rick Lord, VE4OV, **http://winnipegarc.org/NVIS_Lord.pdf**
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Adapted and updated [2020 May 2] by Kai Siwiak, KE4PT

# NVIS

## Material From: “Near Vertical Incidence Skywave, An HF Strategy for Amateur Radio Emergency Service (ARES)”

Adapted with permission, 2019 April 23 and 2020 May 2

Winnipeg Amateur Radio Club, Hamfest 2008, in conjunction with the Radio Amateurs of Canada (RAC) Annual General Meeting

Courtesy of Rick Lord, P.Eng., VE4OV

# NVIS "Cloud Warming?"

- NVIS, pronounced "*NEH*-vis" *in Canada, eh*?

  "*EN-vis*" elsewhere

- Used for generations

- You've probably used it on 80 m

# Your NVIS Signal “Showers” the Area from Zero to About 1000 km

# How Long Have we used NVIS?

- Developed during Second World War
- Proven in Vietnam and Operation Desert Storm
- Used daily by Hams, but we just don't call it by its right name!
- Enjoying a "re-birth"

# NVIS is important for ARES

- NVIS uses HF, not VHF
- No dependence on VHF/UHF Repeaters
- Each HF Mobile is independent
- Massive area coverage from one station
- Not restricted to “line of sight” operation
- Low-power phone HF operation…(as low as 5 Watts!)
- Day / Night and all-season availability

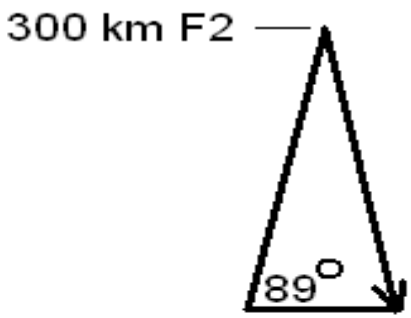
# Why the Ionosphere is Important

- F2 layer is about 300 km up and acts as an “HF Reflector / Refractor”
- Your HF signal is shot up and “showers” back down over a huge area
- The signal path losses for the trip up and back can be so low that modest antennas and low power can achieve an S-9 signal

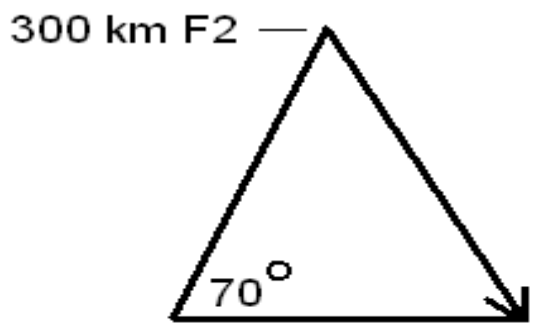
# How do we shoot a signal "straight up", so that it will "shower" the area?

- Use a horizontal dipole or small vertical loop (that is, horizontal polarization upwards)
- Keep antenna low; 0.05 to 0.20 $\lambda$ above ground but with clear view to the horizon
- Use 160 m, 80 m, 60 m, 40 m as required, *depending on how high the FoF2 frequency is*

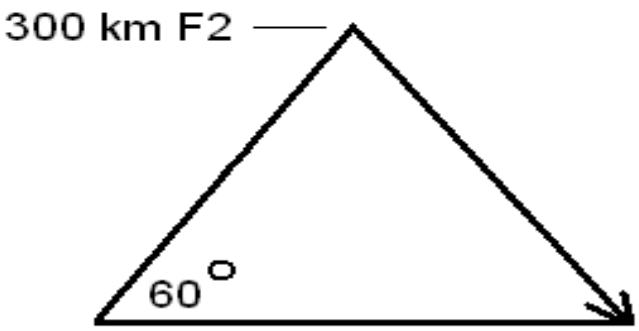
# NVIS Launch Angle Examples



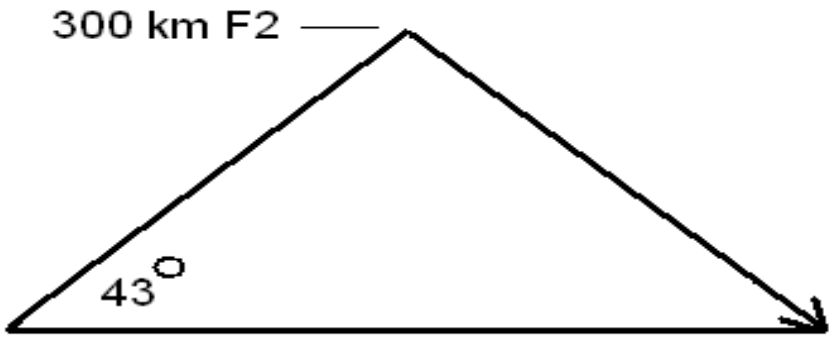

10 km, 6 miles




209 km, 130 miles




328 km, 204 miles

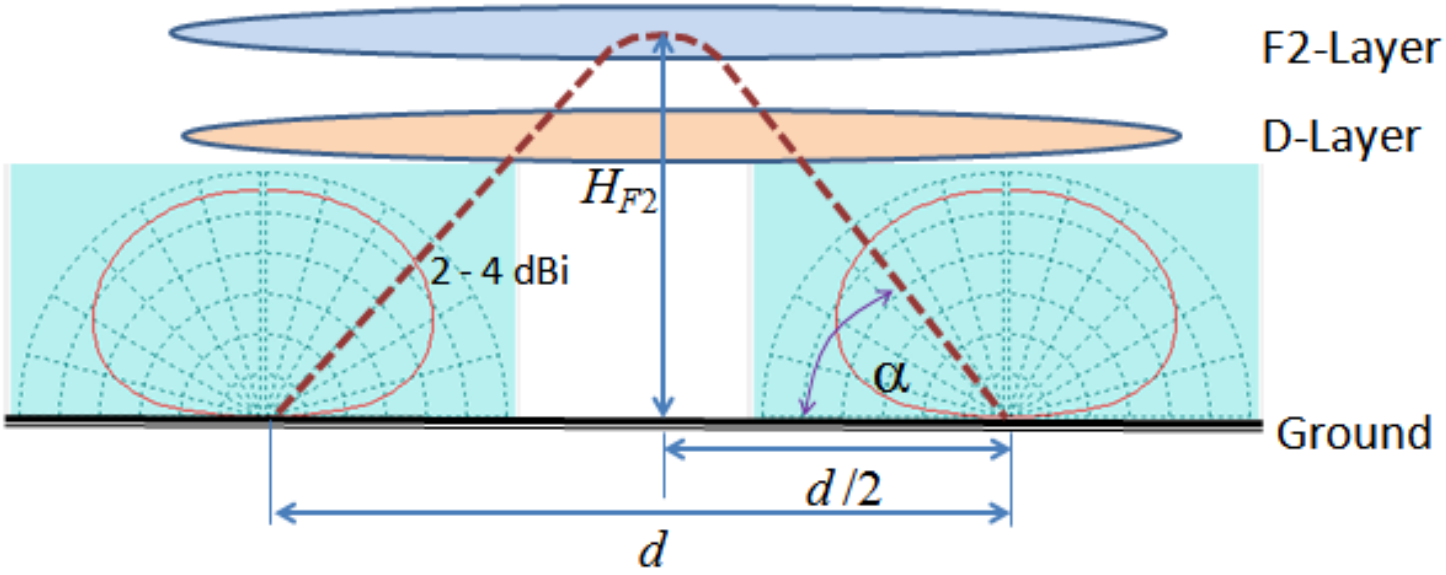



600 km, 373 miles

## An EXAMPLE: NVIS 80 m link between two stations zero to 490 miles (zero to 790 km) apart; no skip zone!

1. Ionospheric path must be present with a MUF of at least 4 MHz. Condition (1) occurs pretty much all day
2. The absorbing ionospheric D layer must be sufficiently dissipated. Condition (2) occurs after local sundown for both stations in the path
3. You must set up antennas that will emit energy at an elevation angle $\alpha$ = 32° to 46°. Condition (3) can be met with horizontally polarized dipoles (inverted V) mounted lower than a quarter wavelength above the ground
4. Each station must have a clear unobstructed view of the horizon in the path direction

# A 490 miles (790 km) NVIS 80 m link:



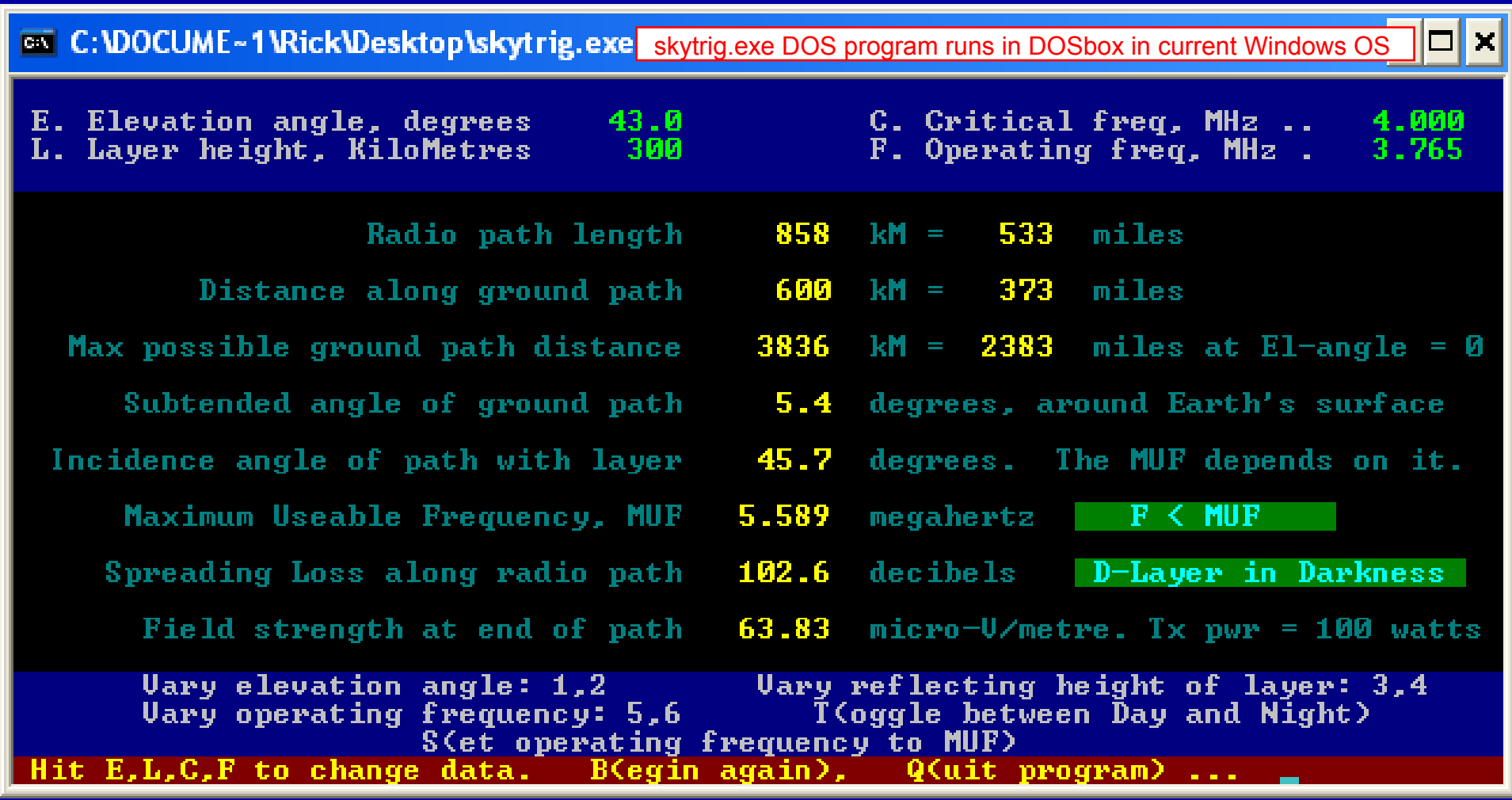

$$\tan(\alpha) = \frac{H_{F2}}{d/2} \quad \text{so} \quad \alpha = \tan^{-1}\left(\frac{H_{F2}}{d/2}\right)$$

$H_{F2} = 250 - 350$ km; $d =$ 790 km so:

$$\alpha = \tan^{-1}\left(\frac{250 \text{ to } 350}{790/2}\right) = 32° \text{ to } 46°$$

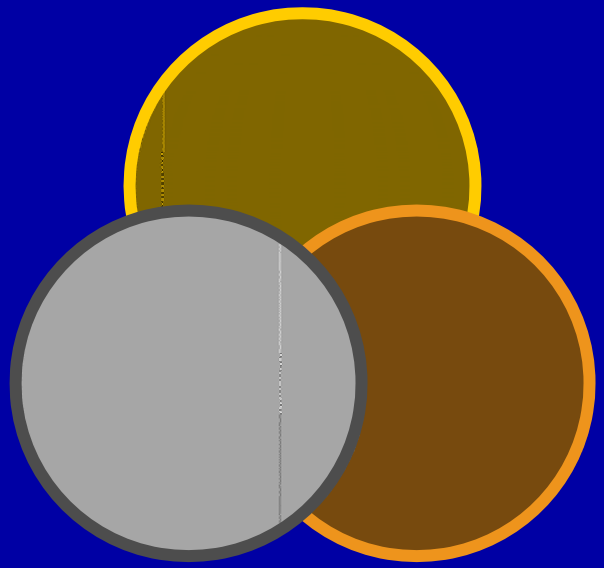
A dipole or inverted V with an apex at 35 - 40 ft would have the patterns show, and would have 2 to 4 dBi (less the matching and implementation losses) at 32° to 46°. A clear view of the horizon is needed on both ends of the path.

# "*Skytrig*" for Path Calculation



# NVIS is a "*Technique*"

WHAT ANTENNA HEIGHT?



WHAT POWER LEVEL?

WHAT FREQUENCY?

# What Power Level?

- A “barefoot” 100 Watt transceiver is more than enough. In fact, 5 Watts is plenty!
- A 5 W transmitter will give a S-9 to S-9+ signal to a similar NVIS Station
- The worst-case path loss is in the 99 dB to 111 dB range for 1000 km range
- This means that low-power rigs can handle the job - good news for portable ARES ops

# What Antenna Height?

- A Horizontal Dipole or Vertical Loop about 0.05 to 0.25 λ above ground is required
- Higher is *not* better
- Depending on the ground conductivity below your NVIS antenna, a 0.2 λ height is about optimum
- Lowering your NVIS antenna *improves* your Signal to Noise Ratio

# What Frequency?

Ah, yes! Here's where the "*Technique*" part comes in:

- One of the 4 "Low Bands" is the correct choice - 160 m, 80 m, 60 m, 40 m
- NVIS propagation restricts these techniques to the "Low Bands", forget about 20 m, 15 m, and up!

# Day Time or Night Time?

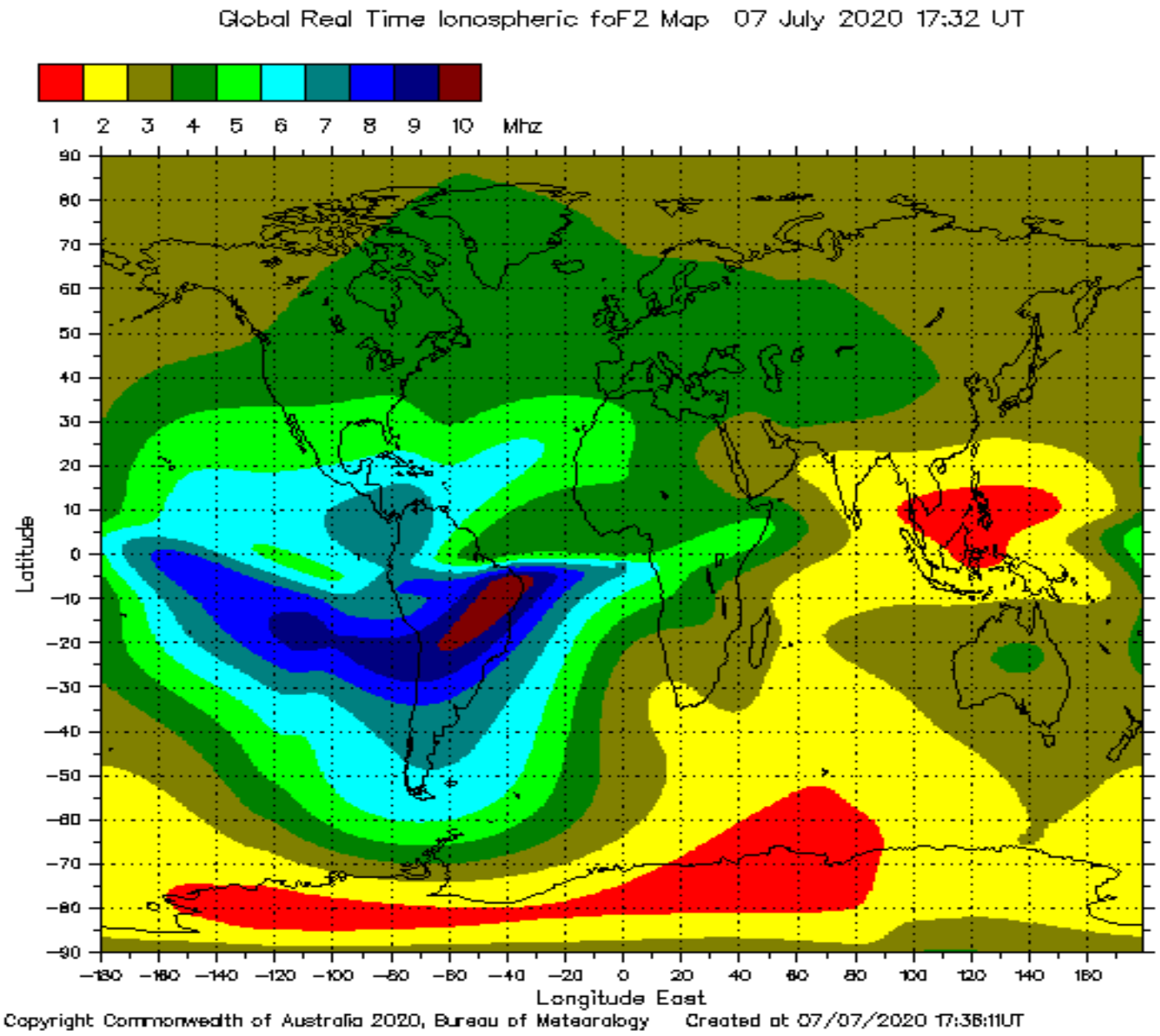
- 160 m is useless during the daytime, due to D-Layer Absorption; *Use 160 m at night!*
- 80 m is adequate during the daytime; Better around dusk, dawn and night time
- 40 m is your best bet for daytime *if FoF2 is high enough*

# FoF2

- FoF2 is the *Critical Frequency* of the F2 Layer. This is the highest frequency that the F2 Layer will return a signal to earth when RF strikes it vertically, that is, “Straight-Up”

- You can get the latest hourly FoF2 world map from the internet, see

  **http://www.sws.bom.gov.au/Images/HF%20Systems/Global%20HF/Ionospheric%20Map/WorldIMap0.gif**


Global Real Time Ionospheric foF2 Map 07 July 2020 17:32 UT
1 2 3 4 5 6 7 8 9 10 Mhz
Latitude
Longitude East
Copyright Commonwealth of Australia 2020, Bureau of Meteorology Created at 07/07/2020 17:38:11UT

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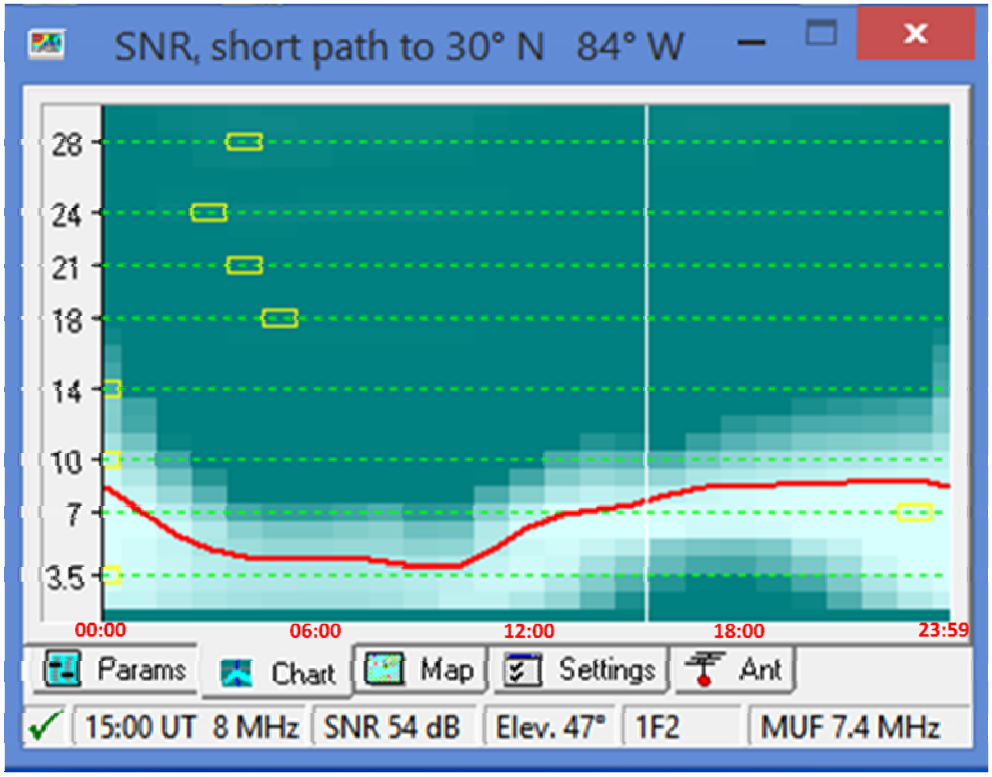
# *HAMCap* 1.91 MUF




**MUF over a 24 hour period** on April 30, 2019

For the F2 layer path

**SFL to Tallahassee, FL**

**Note:**

- 47° elevation angle
- 54 dB SNR/Hz at 100 W
- which is 44 dB/Hz at 10 W!
- [SSB needs SNR/Hz >42 dB for >10 dB (S+N)/N]

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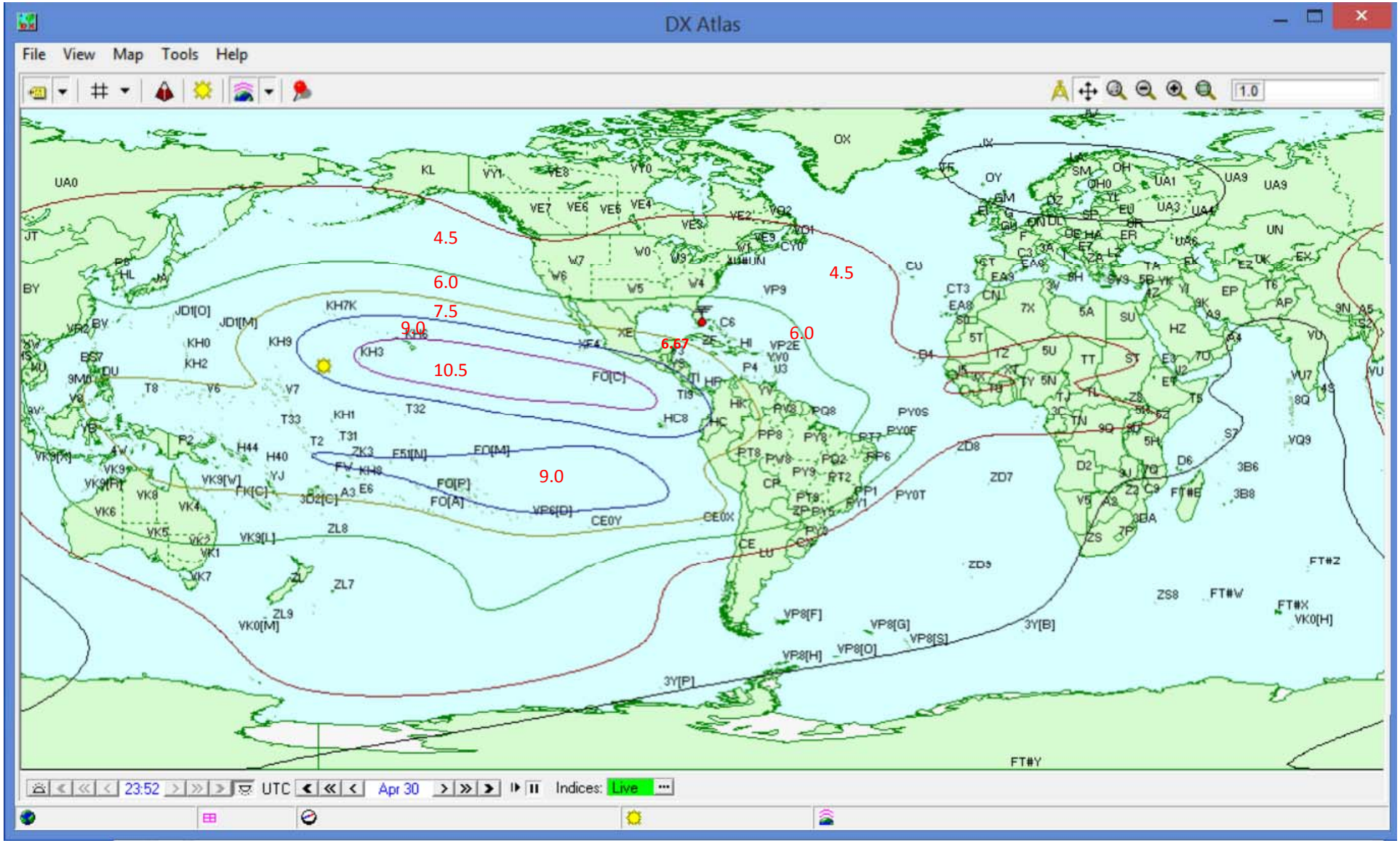
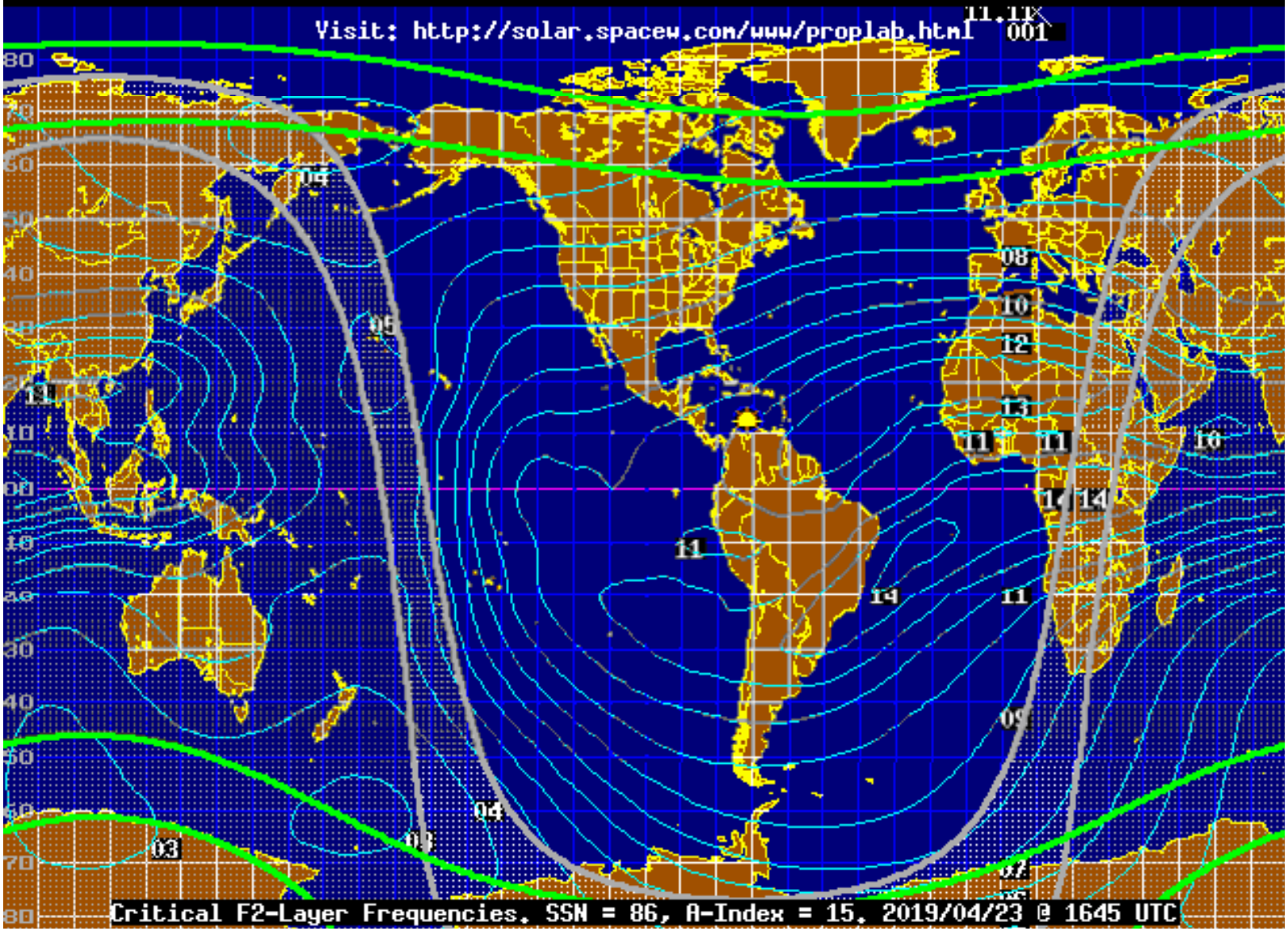
# *DX Atlas* F2 Critical Frequency



# NEW Proplab for Windows 10, Version 3.1

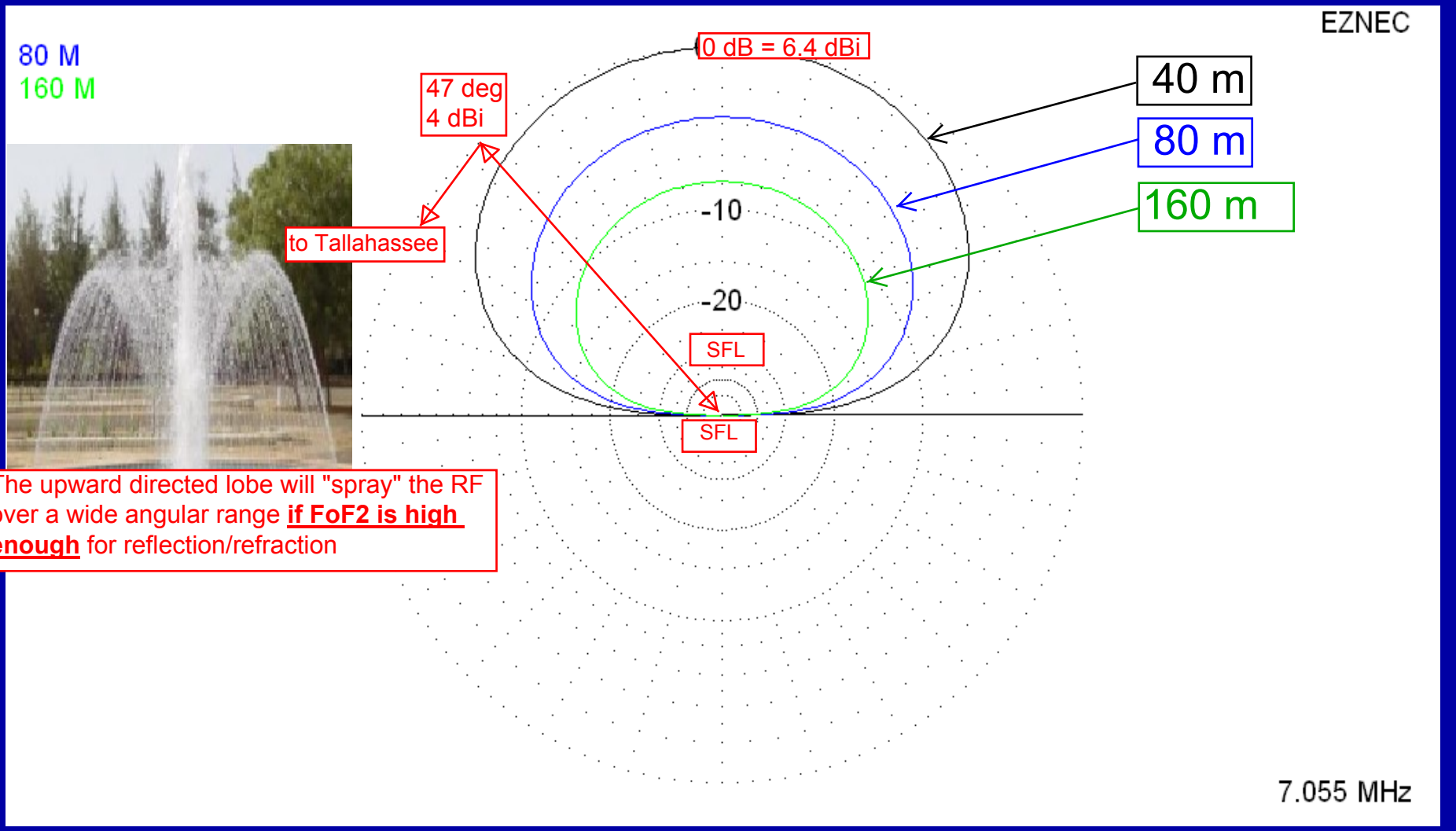
http://www.spacew.com/www/fof2.html



# NVIS Antennas

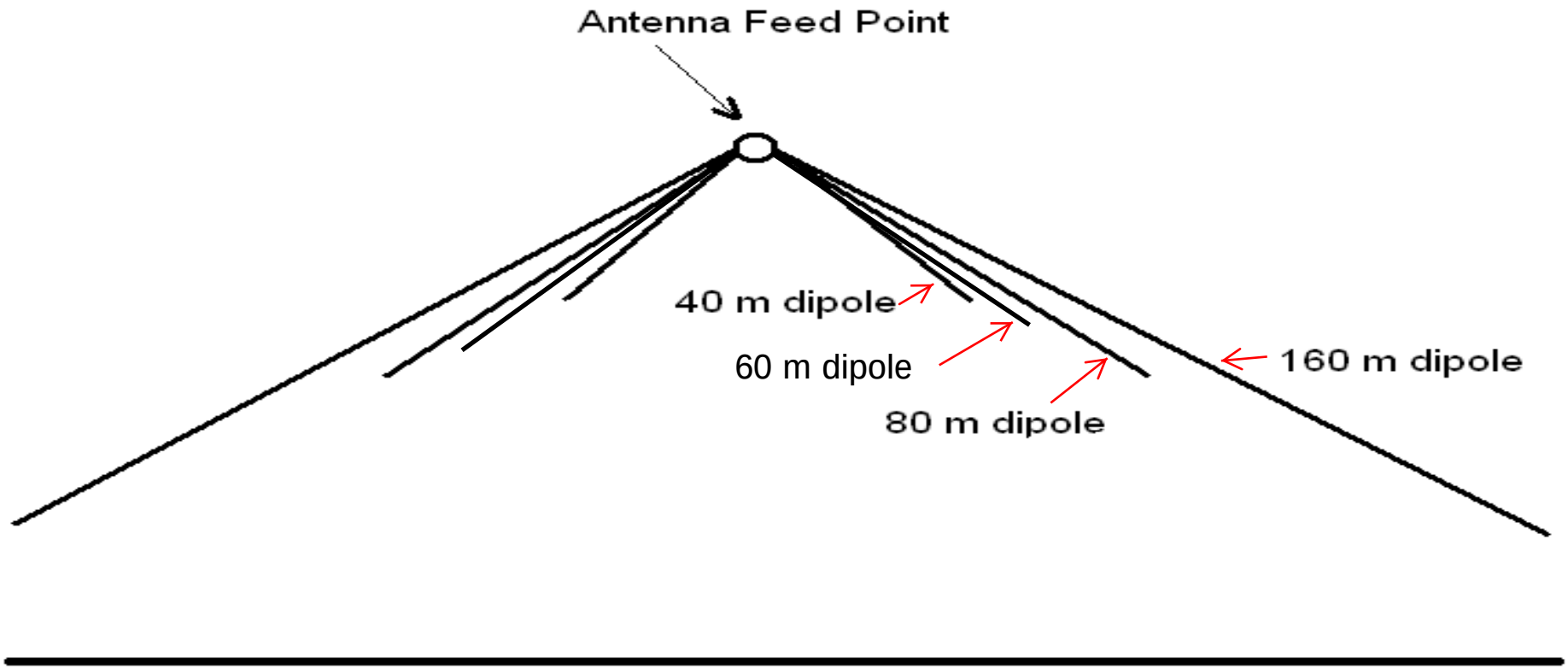
- You need a Horizontal Dipole, or Inverted V, or Small Vertical Loop, but not a vertical antenna, which may leave a skip zone
- Antenna must work over the 160 m, 80 m, 60 m and 40 m bands
- Could be 3 - 4 antennas fed from a common transmission line

# Example NVIS Loop Elevation Plot




The upward directed lobe will "spray" the RF over a wide angular range **if FoF2 is high enough** for reflection/refraction

# NVIS Four-dipole Inverted V



# NVIS "Re-Cap"

- NVIS is a *Technique*…( *not an antenna!* )
- Equipment and power levels are straight forward and usual for HF Operation
- The unique things about NVIS are the low horizontally polarized antennas, and the need to operate close to FoF2, the F2 Critical Frequency
- NVIS techniques "Silver Bullet" for ARES HF

# NVIS Comments by John Stanley, K4ERO

- NVIS occurs whenever the fxF2 is above the operating frequency
- The fxF2 is about 500 kHz above the foF2
- During the daytime, D layer absorption reduces NVIS signals, and this makes operation about 15% below the foF2 optimum for strongest signals
- This frequency is called the FOT (optimum traffic frequency), but transmissions way below the FOT can be very reliable provided the path loss is covered by either high power or sensitive modes, like the digital modes, and/or a quiet receive location
- NVIS is not difficult, in fact if you are below fxF2 it is unavoidable
- Antennas can either aid it or try to suppress it, but it will still be there.

# References


SkyTrig: R.J. Edwards, G4FGQ, ( SK ): http://www.wireless.org.uk/g4fgq/page3.html

Solar Terrestrial Activity Report: http://www.dxlc.com/solar/

Australian Government: Ionospheric Prediction Service: HAP Charts: IPS Radio & Space Services
http://www.ips.au/hf_systems/4/1

ARES Edmonton AB: Blaine Osepchuk, VE6BKO
http://members.shaw.ca/ve6bko/overview.html
http://members.shaw.ca/ve6bko/update01.html

Dr. Marc C. Tarplee, Ph.D., N4UFP: Near Vertical Incidence Skywave (NVIS).ppt
http://www.arrl-sc.org/tech_presentations_by_n4ufp_tc.htm

EZNEC: Antenna Software by W7EL, Roy Lewallen, P.E., W7EL
http://www.eznec.com

HamCap 1.5 Alex Shovkoplyas, VE3NEA
http://www.dxatlas.com/hamcap/

RAC/TCA Amateur Radio Calculators: Professor Emeritus David Conn, Ph.D., P.Eng., VE3KL
"Field Strength" and " Received Power and Path Loss"

# References

| | |
|---|---|
| Real time maps at: | **http://www.sws.bom.gov.au/Images/HF%20Systems/Global%20HF/Ionospheric%20Map/WorldIMap0.gif** |
| *SkyTrig.exe* | **http://wireless.org.uk/g4fgq/skytrig.exe** can be run in Windows 8.1-10 in DOSBox: **https://www.dosbox.com/** |
| *Proplab* for Win 10: | **http://shop.spacew.com** |
| *DXAtlas* & *HamCAP*: | Alex Shovkoplyas, VE3NEA, **http://www.dxatlas.com/** |
| 4*nec*2: | Arie Voors, NEC based antenna modeler and optimizer, **www.qsl.net/4nec2/** |

# NVIS Propagation with ARES in Mind

Thank you, Questions?

73, Kai, KE4PT