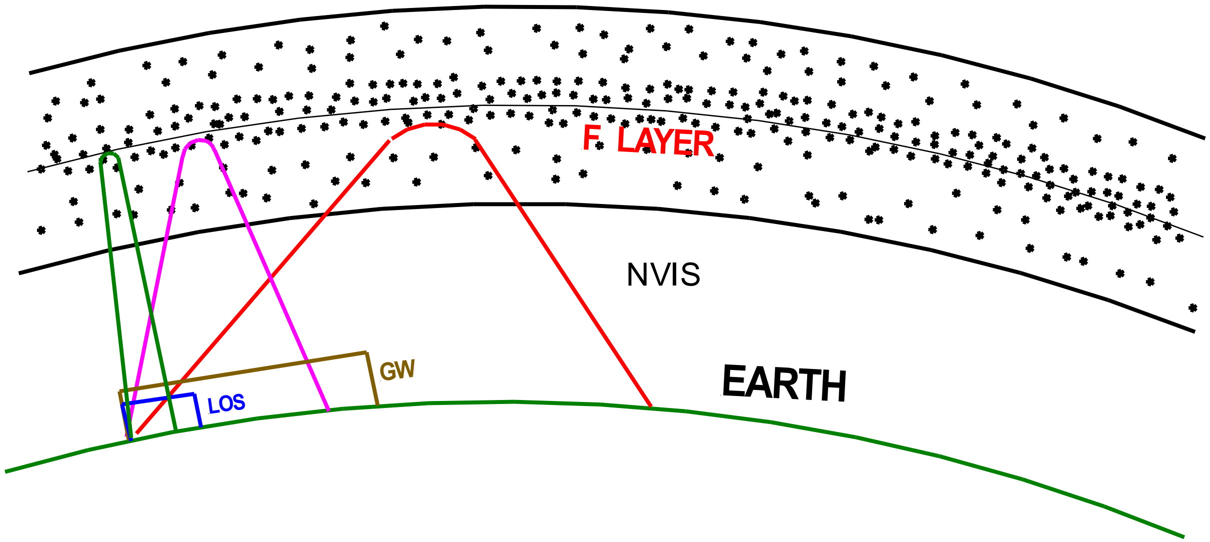
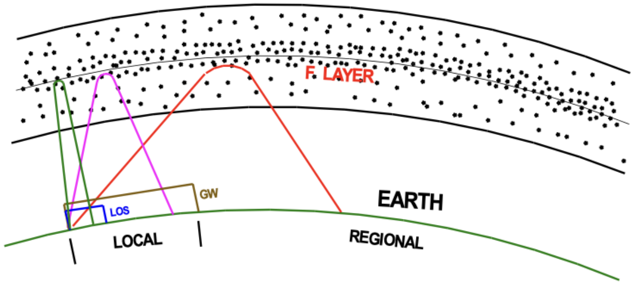
# NVIS Communications

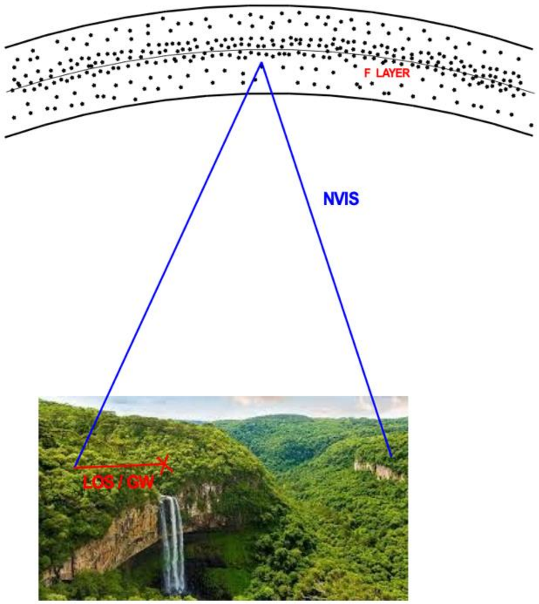




Ken Larson KJ6RZ
August 2025
www.skywave-radio.org

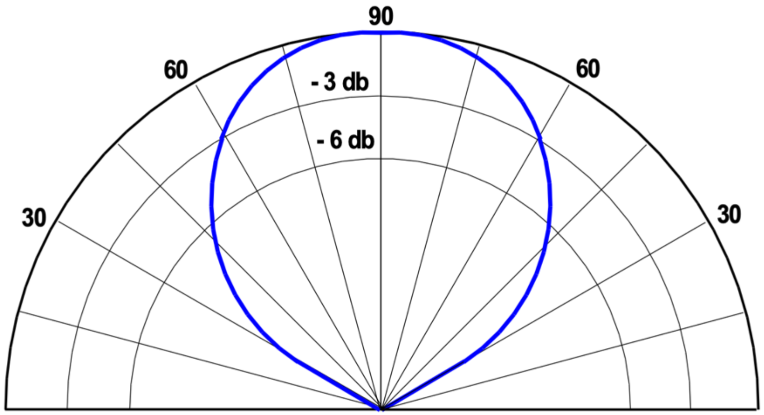
# NVIS Is Important !



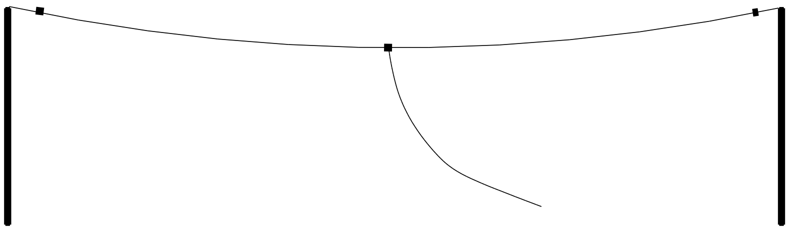




- **Near Vertical Incident Skywave (NVIS) is a powerful mode of HF communications**
- It is heavily used for local and regional radio communications, including
- In mountainous and jungle regions where other forms of radio communications are impossible
- It is extensively used for emergency operations, and
- For modern day military communications

# What Is NVIS ?




**NVIS Antenna Pattern**

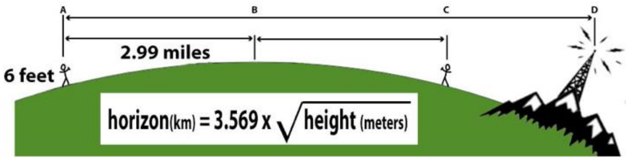


Author

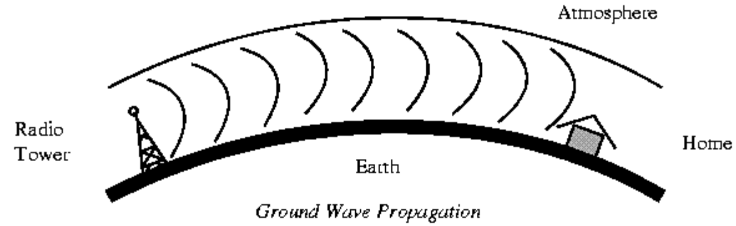
**NVIS Antenna**

- **NVIS is simply radio communications using HF signals that are transmitted at high elevation angles, i.e. at greater than 60°**
- It is the high elevation angles that makes NVIS so important
- NVIS signals are radiated by low horizontal antennas less than 1/4 wavelength above ground

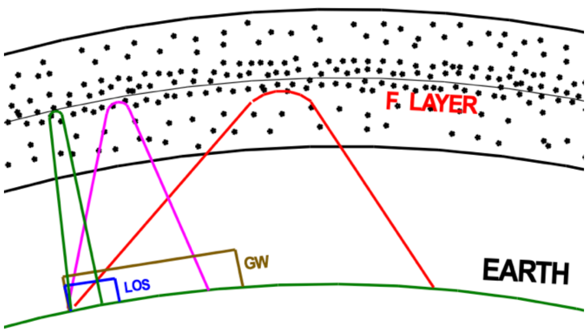
# Local HF Communications




Line of Sight



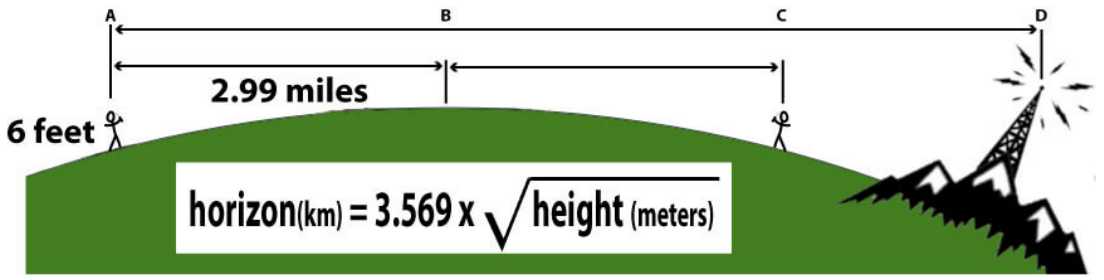

Ground Wave




Near Vertical Incident Skywave

- There are 3 modes of local HF propagation
- Line of Sight (LOS), Ground Wave (GW), and Near Vertical Incident Skywave (NVIS)
- These are the only possible modes for local HF communications

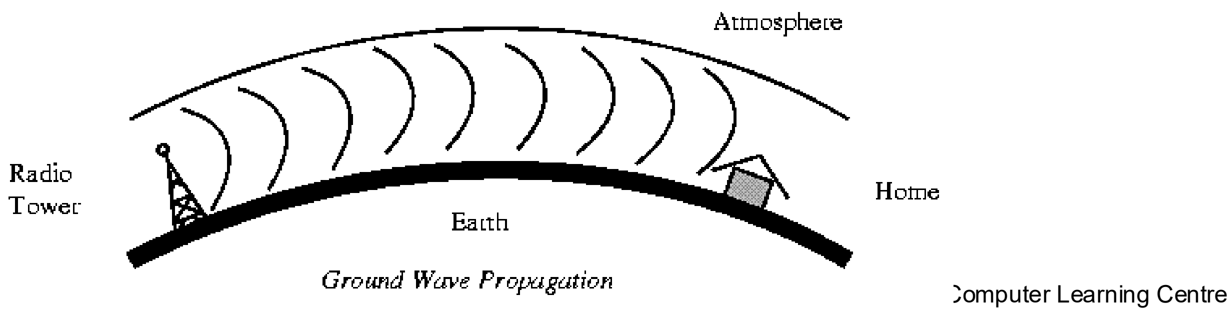
# Line of Sight Propagation




HTQ Solutions

- HF line of sight propagation is very similar to communicating on 2 meters, 220, and 440 MHz
- The distance covered by LOS depends on the height of the transmitting and receiving antennas
- In the figure above the LOS distance between two people with handheld radios is approximately 6 miles
- The LOS distance between a person with a handheld radio and a repeater on a mountain top is greater as the above equation indicates
- The HF LOS distance from my antenna (height = 30 ft) to a similar receiving antenna is approximately 13.4 miles, presuming the local hills don’t get in the way which unfortunately they do

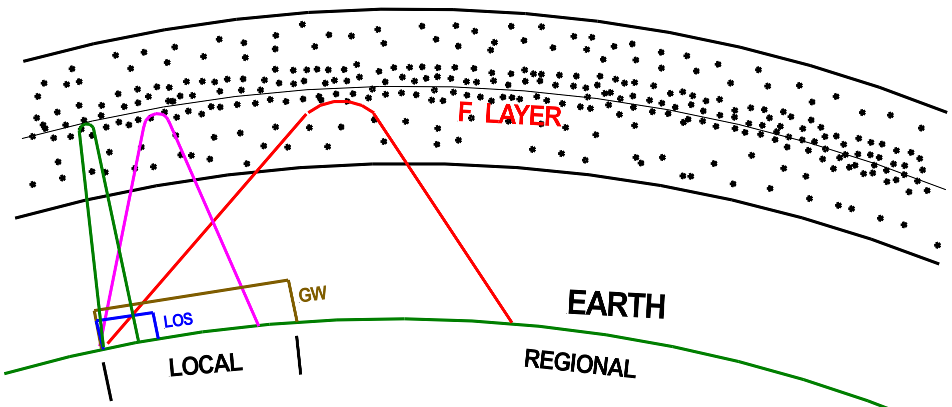
# Ground Wave Propagation

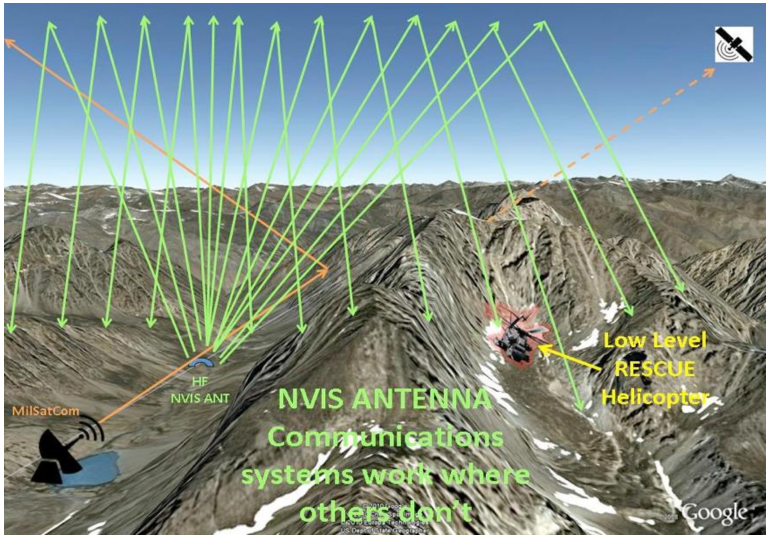



| Frequency Band | Typical Ground Wave Distance |
|---|---|
| 80 meters | 68 miles |
| 40 meters | 50 miles |
| 20 meters | 30 miles |

- Ground wave propagation range depends on Frequency, Terrain, and Soil Conditions
- Ground wave range decreases with increasing frequency as shown in above chart
- Ground wave distances shown above occur over flat terrain and excellent soil
- In Ventura County with many hills, mountains, and rocky soil ground wave propagation range is much less (15 to 20 miles on 40 meters if we are lucky)

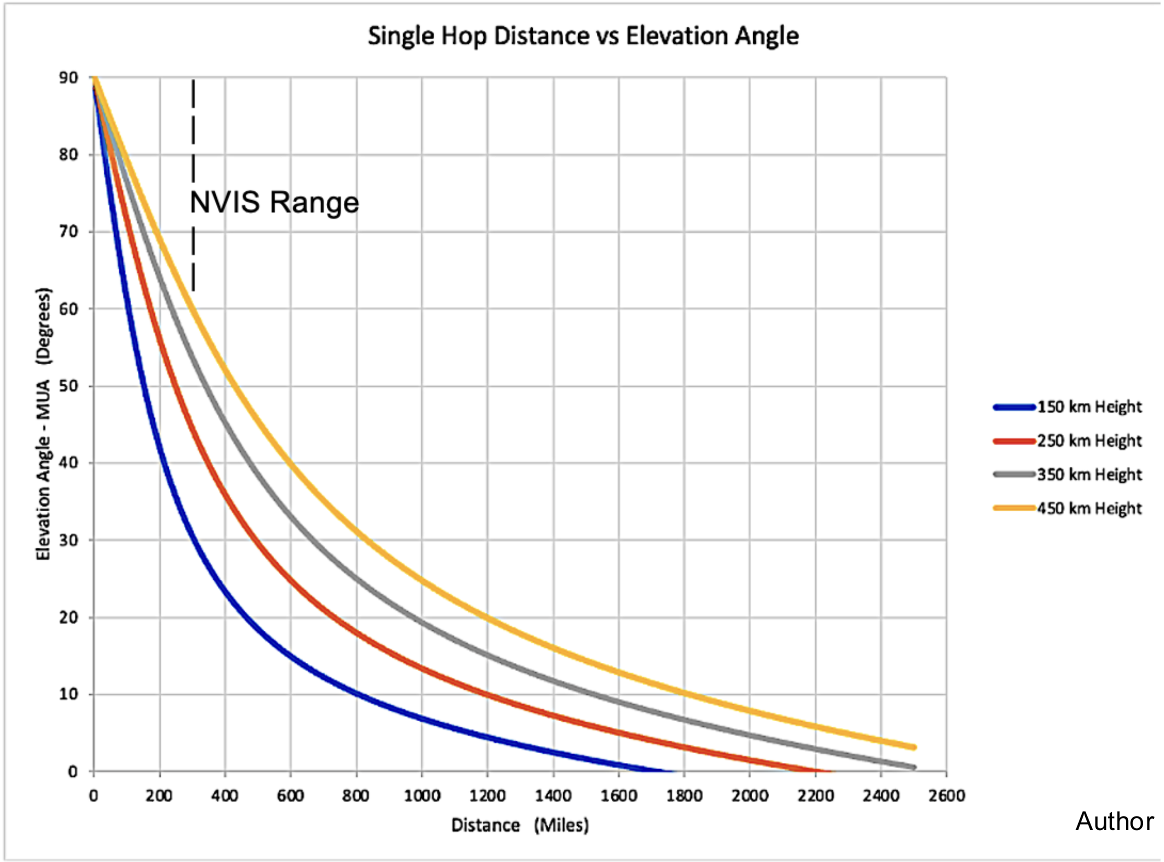
# NVIS Coverage



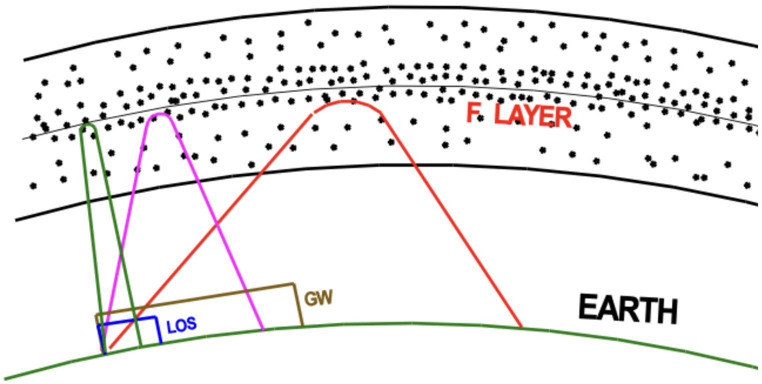

- NVIS along with LOS and GW provide **local** HF communications (green and magenta traces)
- NVIS also provides communications to radio stations up to 300 miles from the transmitting station, i.e. to stations beyond the range of local LOS and GW propagation (the red trace)
- From a communications perspective **regional area** can be defined as the area covered by NVIS propagation
- NVIS provides coverage to **all** radio stations in the regional area

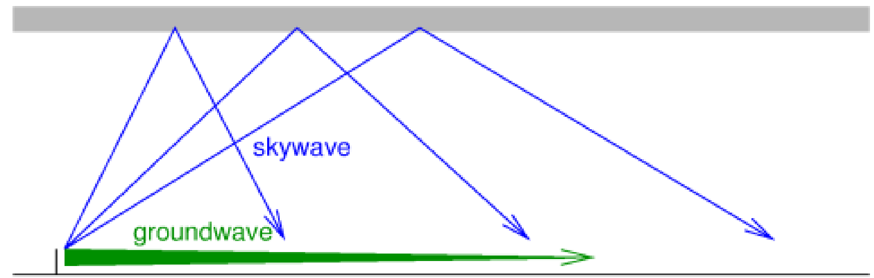
# NVIS Range




- At an elevation angle of 60°, the NVIS propagation range is 200 to 300 miles
- A transition zone of NVIS propagation, with low D Layer absorption, typically extends out 350 to 380 miles
- Beyond 400 miles we encounter oblique propagation conditions including moderate to high levels of D Layer absorption, skip zones, Maximum Usable Frequency, etc.

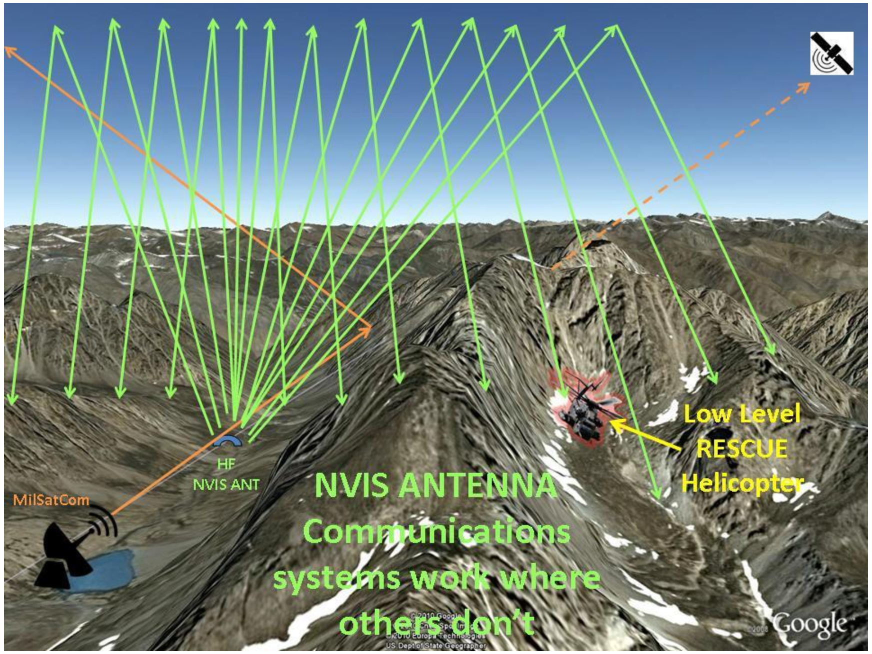
# Local Communication Problems




- There are local communication problems that we need to be aware of
- Line-of-site (LOS) and ground wave (GW) propagation always exist
- Consequently, multi-path interference problems between NVIS, ground wave, and line-of-site signals can sometimes occur
- Multi-path interference occurs when two signals (NVIS and GW for example) traveling via different paths arrive at the receiving site with the same signal strength but out of phase
- The two signals will completely cancel out if they are 180$^{o}$ out of phase, meaning that neither signal is heard by the receiving station
- Multi-path interference results in signal degradation, fading and perhaps complete signal lose

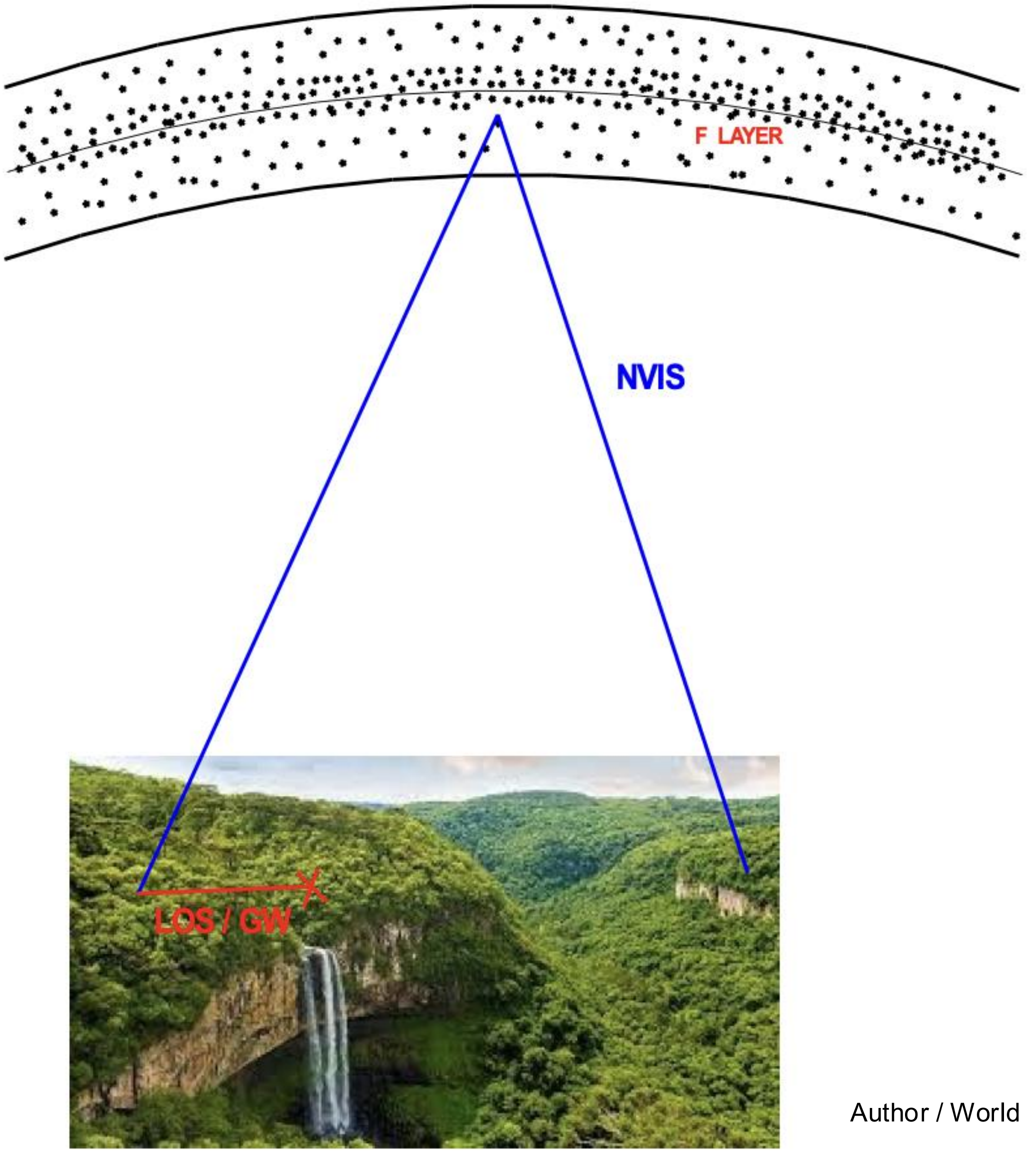
# NVIS Communications in Mountainous Terrain




AFCEA International

- NVIS communications work well in mountainous terrain where other forms of radio communications do not
- Radio systems precluded from use in mountainous terrain include: low angle long distance HF, line of sight VHF, UHF, and often satellite communications
- Local HF line of sight and ground wave propagation are also precluded
- Due to its high elevation angle NVIS is often the only means of radio communications into and out of deep mountain valleys and canyons

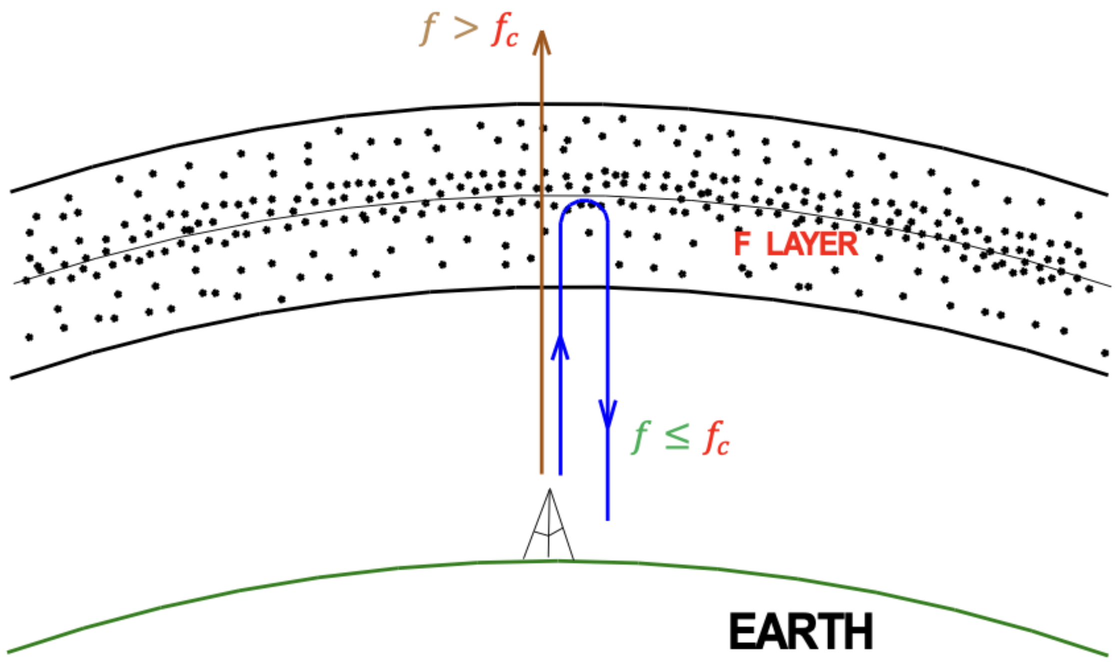
# NVIS Communications In Jungle Regions




Author / World Walks

- NVIS signals quickly penetrate the jungle canopy avoiding severe signal attenuation caused by lush often wet jungle vegetation
- In contrast Line Of Sight (LOS) and Ground Wave (GW) signals typically propagate only a mile or two before being completely absorbed by the dense jungle vegetation
- Example, HF emergency communications in Puerto Rico following Hurricane Maria in 2017

# NVIS Depends On The Ionosphere's Critical Frequency



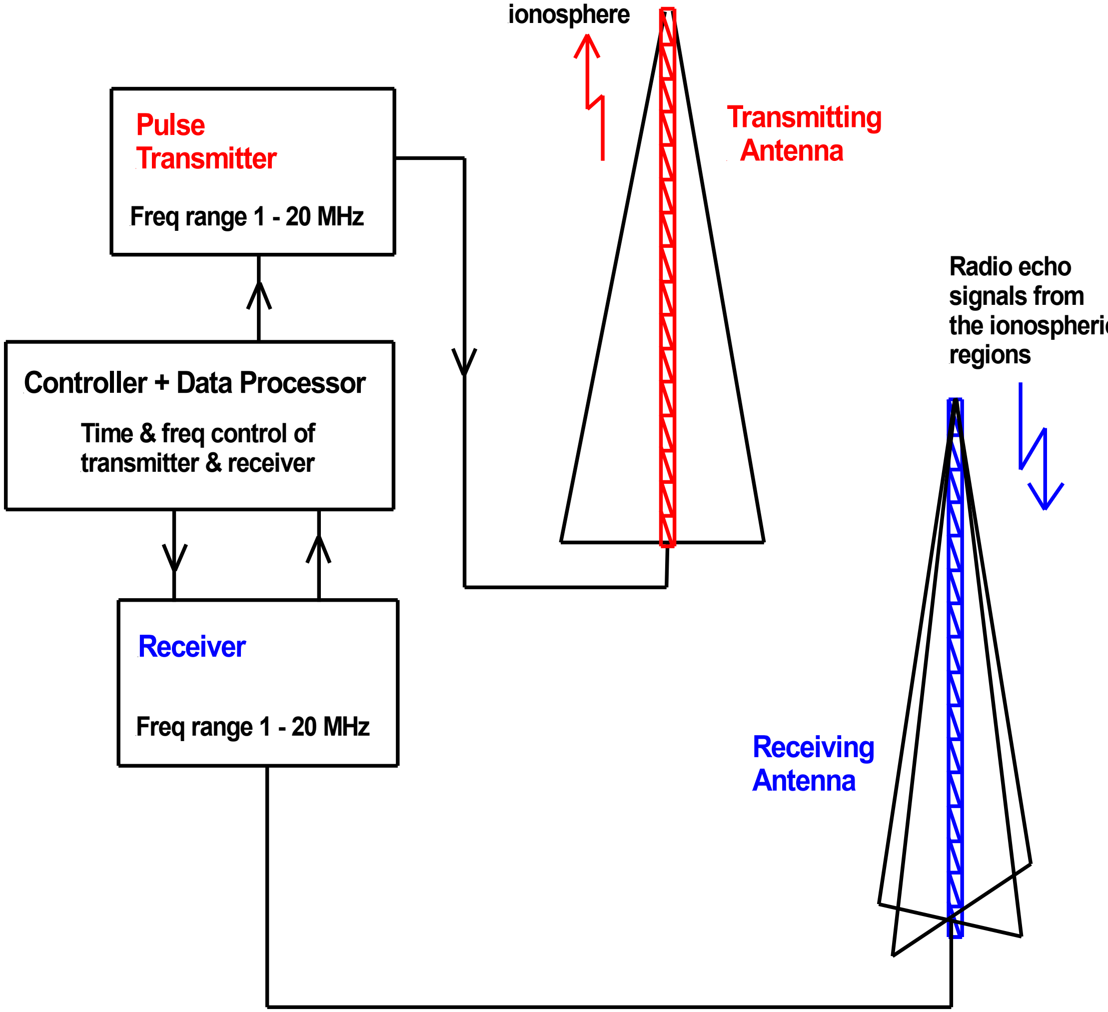

Author

- The ionosphere's Critical Frequency $f_c$ is the **highest** frequency signal that can be transmitted straight up and reflected back down to Earth
- Signals higher in frequency transmitted straight up will penetrate the ionosphere and be lost to outer space
- All signals lower in frequency than $f_c$ will be reflected back to Earth, these are the NVIS frequencies

# Determining the Current Critical Frequency

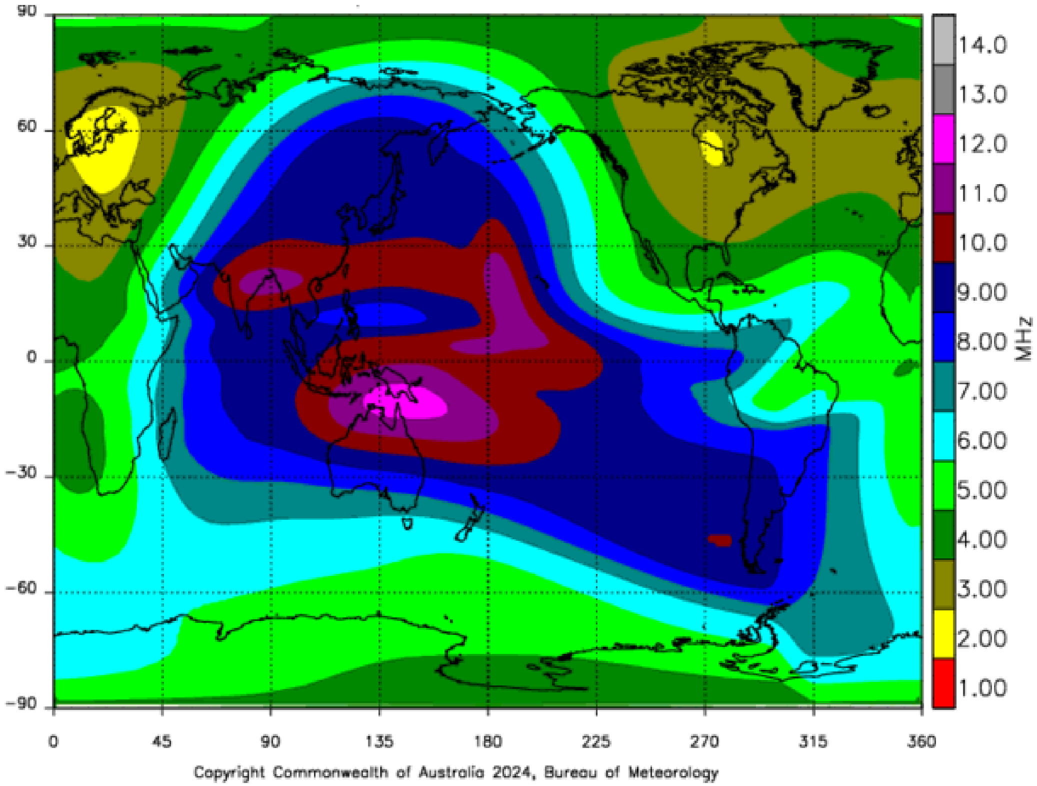
- Ground based sounders, known as ionosondes, are used around the world to determine local critical frequencies
- Our closest ionosonde in California is located just south of Vandenburg AFB


Ionosonde controller & data processor




spaceacademy.net.au

# Global Critical Frequency Map



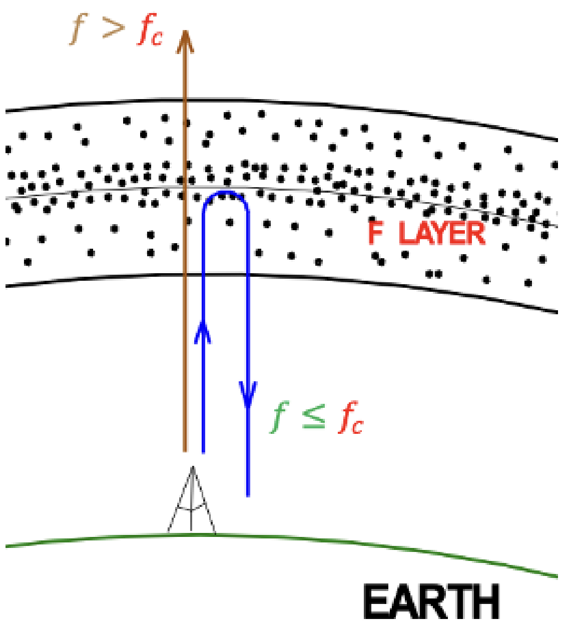

This chart shows the Critical Frequency for January 31, 2024 at 03:00 UT

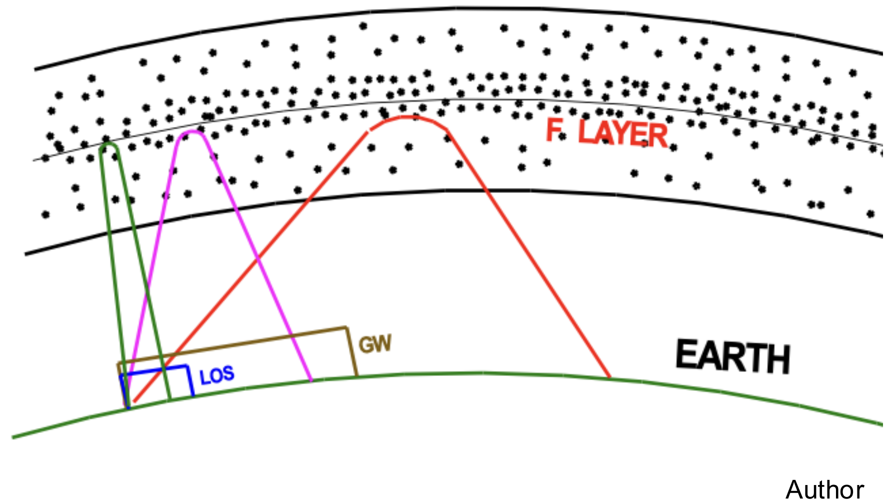
Over California the Critical Frequency was between 4 to 5 MHz

Critical frequency in Northern Europe was 2 MHz

- **Critical frequency is very important in NVIS communications**
- So where do you find the ionosphere's current critical frequency?
- The Australian Government produces a global F2 critical frequency map that is available under the Current Conditions tab on the www.skywave-radio.org website
- The critical frequency map is updated every 15 minutes
- The map is created automatically from reports received from ionosonde monitoring stations around the world

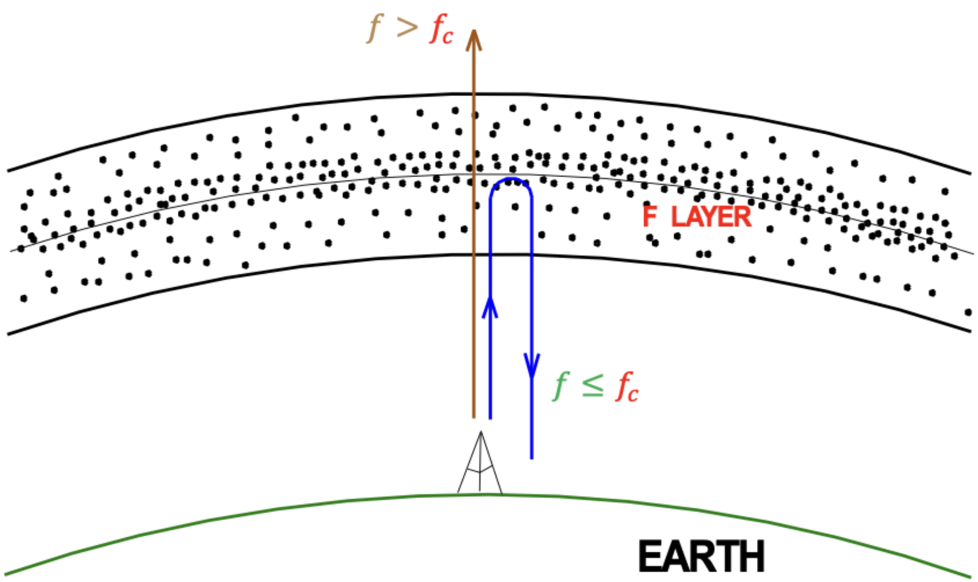
# NVIS Propagation vs Critical Frequency




- **NVIS propagation is only possible if the NVIS transmitting frequency f is below the ionosphere's critical frequency $f_c$** → this makes sense
- Critical frequency is the highest frequency that can be transmitted straight up and reflected back to Earth
- A higher frequency signal transmitted nearly straight up (an NVIS signal) will penetrate the ionosphere and be lost to outer space
- **Thus NVIS communications is only possible for frequencies below the critical frequency**

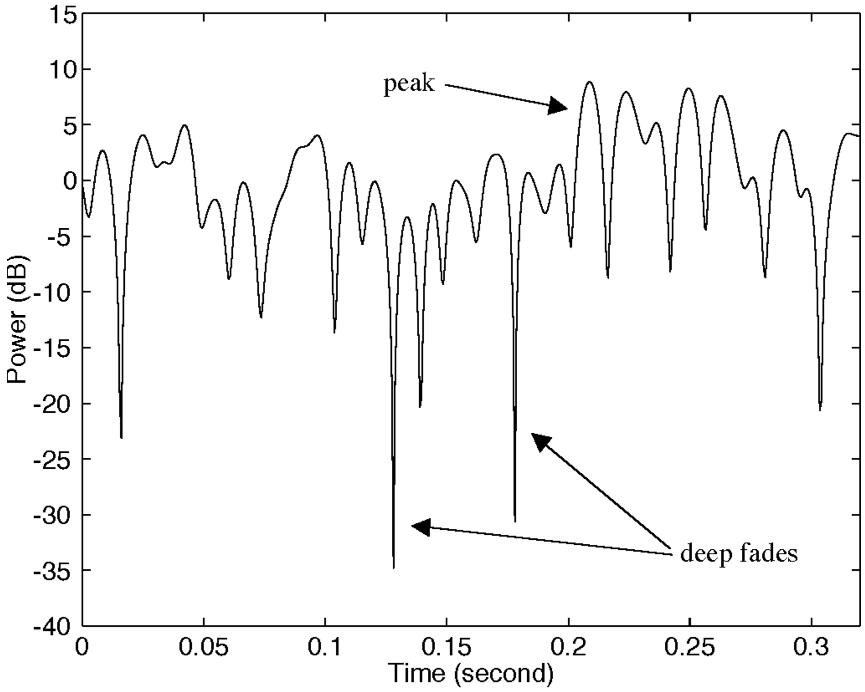
# NVIS Propagation vs Critical Frequency Example




Author

- For example, if the current critical frequency is 8 MHz, then NVIS propagation will be excellent on 40 and 80 meters since both frequency bands (7.0 MHz and 3.5 MHz respectively) are below the 8 MHz critical frequency.
- However, if the critical frequency drops to 6 MHz, then NVIS propagation will no longer be possible on 40 meters, but it will still be good on 80 meters
- If the critical frequency drops to 6 MHz or lower we must change our operating frequency from 40 to 80 meters
- **Frequency agility is an important aspect of NVIS comm**unications

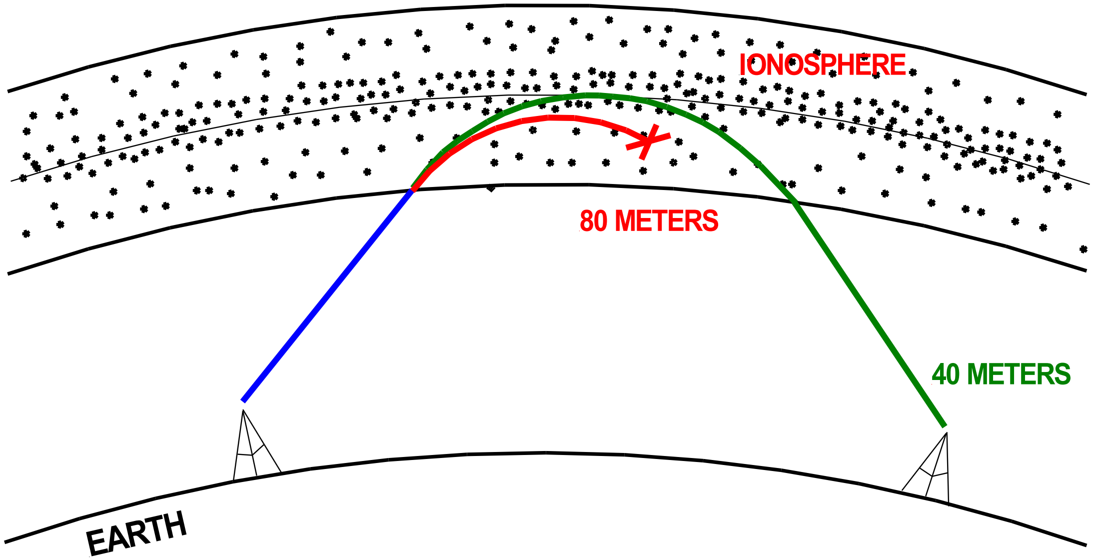
# NVIS Fading




Ericsson Inc

- Critical frequency continuously drifts up and down in frequency
- A critical frequency of 7 MHz may drift to 7.6 MHz and then down to 6.5 MHz
- Consequently, a 40 meter (7.2 MHz) signal fades in and out as the critical frequency drifts above and below the transmitting frequency
- To avoid fading operating at a frequency at least 10% below the critical frequency is recommended

# D – Layer Absorption

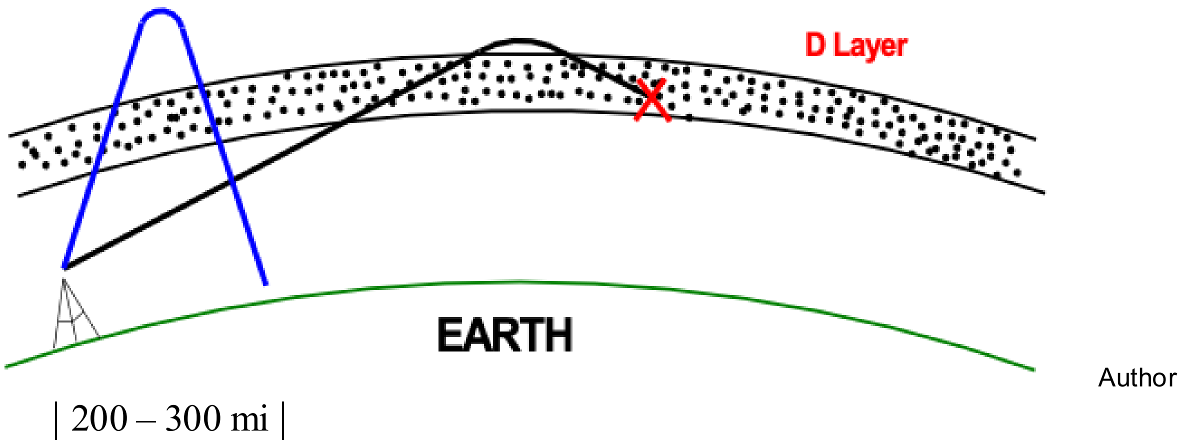



Author

$$\text{Absorption} \propto \frac{1}{f^2}$$

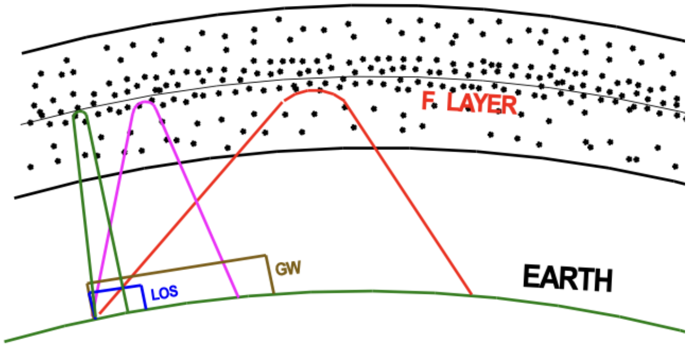
- D Layer absorption is inversely proportional to frequency squared
- For example: absorption is 4 times greater on 80 meters than on 40 meters
- To minimize D-Layer absorption, operate on the highest available frequency band that is at least 10% below the critical frequency
- If both 40 and 80 meters are below the critical frequency, operate on 40 meters to minimize D-Layer absorption

# 40 Meter Mid Day NVIS is Excellent

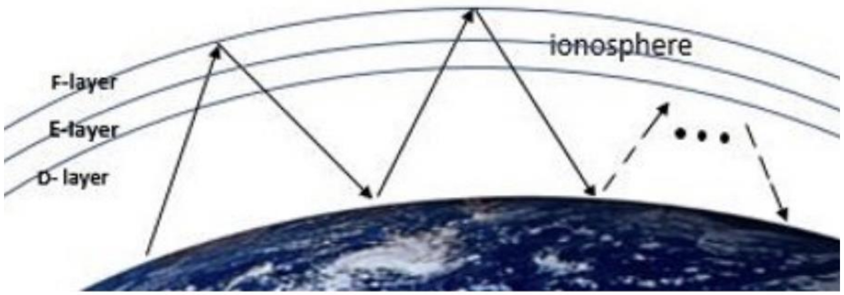



- Excellent 40 meter NVIS occurs throughout the day, in particular during mid day when D-Layer absorption is greatest
- The reason for this is that the high elevation angle NVIS signals (blue trace) pass through the D-Layer quickly incurring little absorption
- However, long distance low angle 40 meter signals spend more time passing through the D-Layer often resulting in complete D-Layer absorption
- This is very important: Using **NVIS propagation** (40 meters during the day and 80 meters at night) we can reliably communicate nearly 24 hours per day 7 days per week
- NVIS is a powerful mode !

# Low Power NVIS Communications




Author

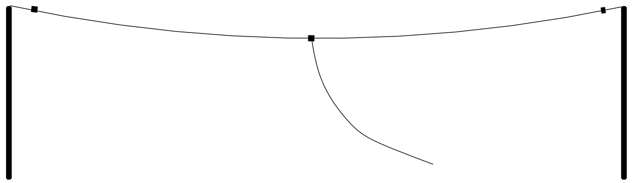


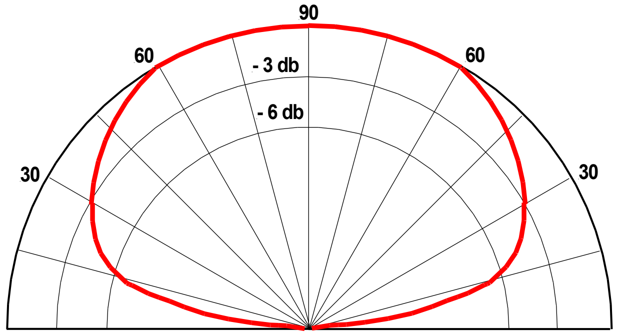

ResearchGate

- NVIS Operation at higher power levels is necessary under adverse conditions and when fighting multipath interference problems
- Typically, however, excellent NVIS communications is achieved using 10 to 15 Watts
- The reason is that NVIS path lengths are very short (a single short hop through the ionosphere) incurring very little signal attenuation
- In comparison, a low angle long distance multi-hop signal covering thousands of miles is highly attenuated by the time it reaches the receiving station
- Battery power is often utilized for 2 meter and 440 local communications at 10 to 15W
- The low power requirements of NVIS means that regional HF emergency communications out 200 to 300 miles can also be achieved using battery power
- Battery powered stations can often handle all of our emergency communication needs !

# NVIS Antennas

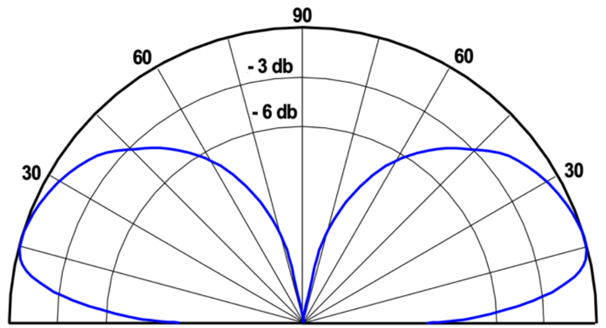
Horizontal Antenna






NVIS 1/2 Wave Dipole 1/4 Wavelenth Above Ground

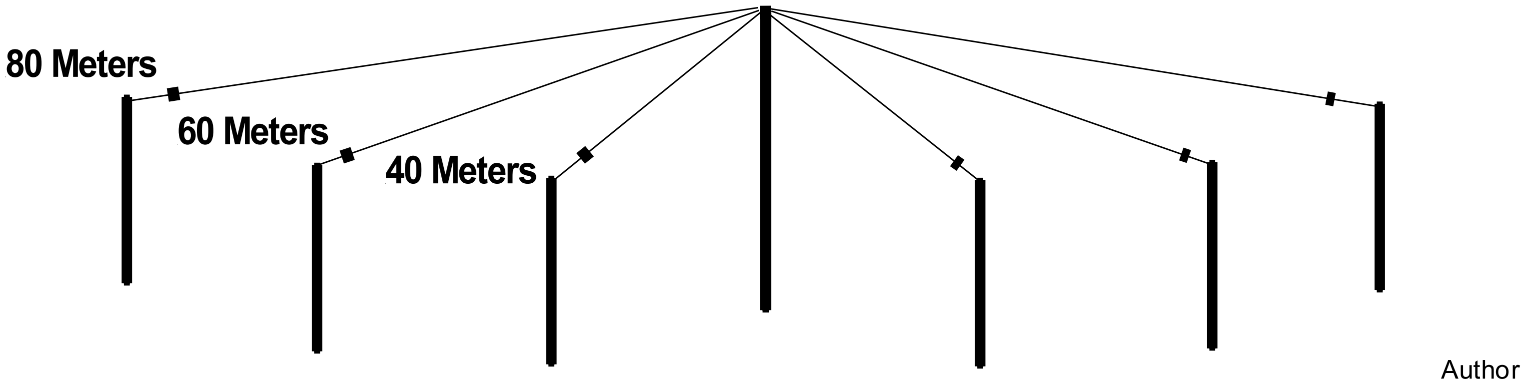
Vertical Antenna




1/4 Wave Vertical Antenna Over Very Good Ground

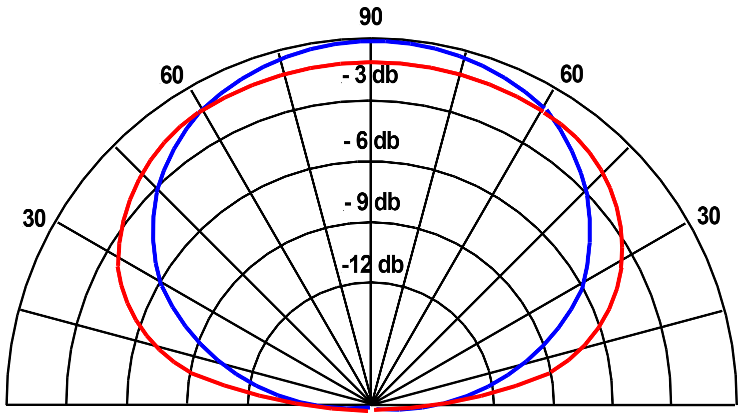
- Horizontal antennas that are less than 1/4 wavelength above ground radiate high angle NVIS signals
- Vertical antennas are not well suited to NVIS but provide better ground wave propagation than horizontal antennas
- Line of sight propagation is provided by both horizontal and vertical antennas

# Multi-band Inverted V NVIS Antenna



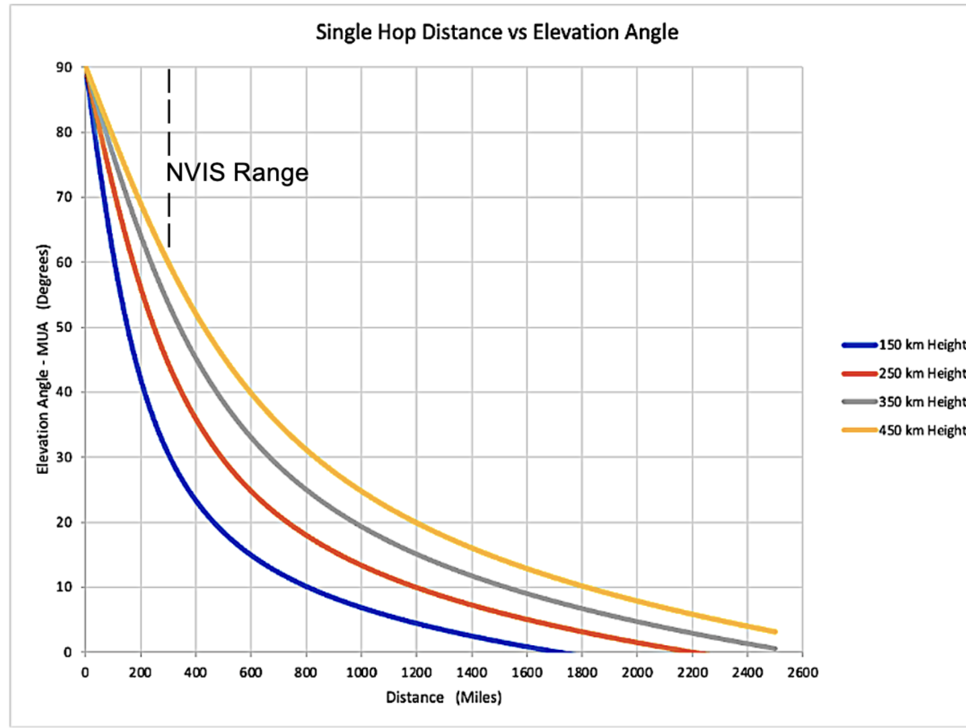

- A multi-band Inverted V antenna covering 40, 60, and 80 meters is an excellent NVIS antenna system ---- **remember the need for frequency agility**
- At an apex height of 32 feet, the 40 meter antenna is 1/4 wavelength above ground while the 80 meter antenna is 1/8 wavelength above ground
- 60 meters is an ideal NVIS band when the critical frequency is below 40 meters and D-Layer absorption on 80 meters is excessive

# Height Above Ground



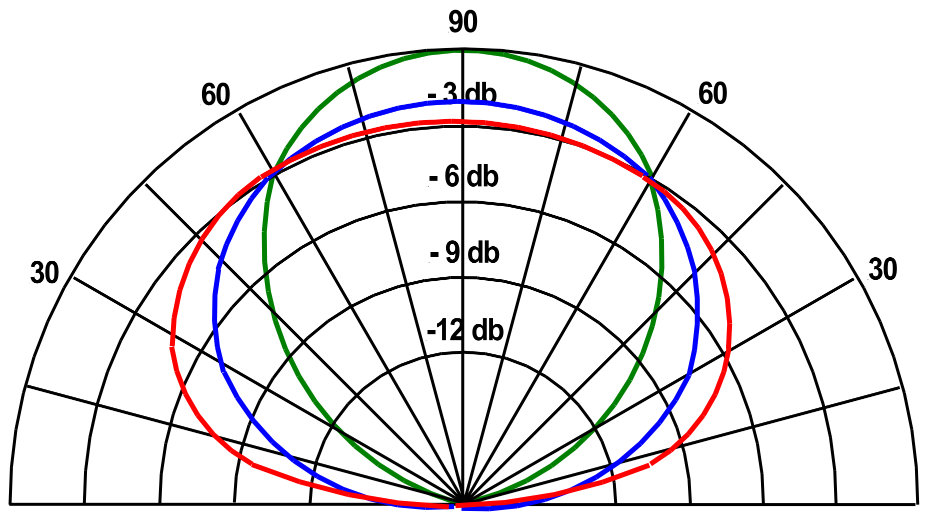

NVIS Antenna Patterns
1/4 wavelength above ground
1/8 wavelength above ground

Author

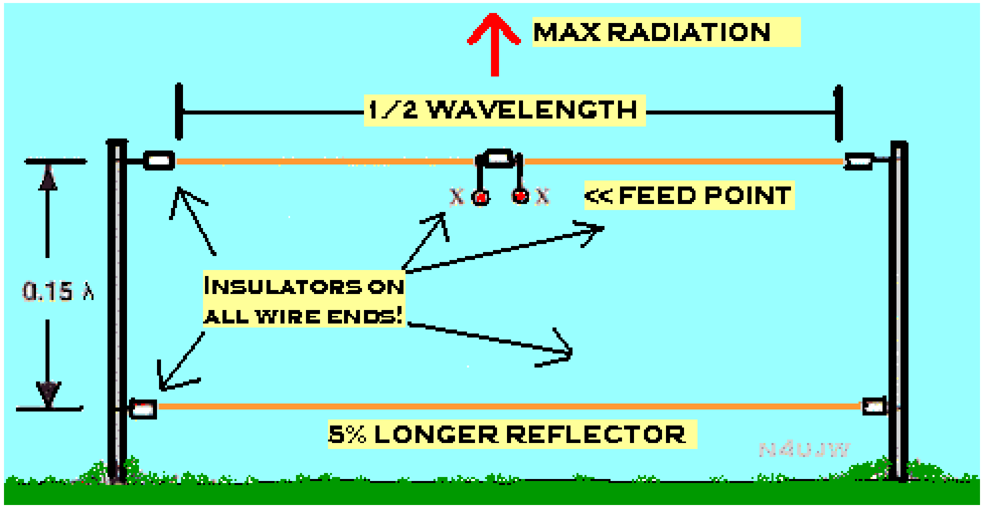



- The -3db point in an antenna pattern is the elevation angle at which the antenna's signal strength drops 3db below its peak value (for NVIS its peak value occurs at 90 $^{o}$)
- The -3db point for a NVIS antenna 1/4 wavelength above ground its approximately 30$^{o}$
- At this elevation angle its single hop distance is roughly 600 miles
- The vertical radiation pattern of a NVIS antenna improves slightly by dropping its height from 1/4 to 1/8 wavelength above ground
- However, for a antenna 1/8 wavelength above ground its -3db elevation angle is approximately 45$^{o}$ with a corresponding single hop distance of roughly 400 miles

# 2 Element NVIS Antenna



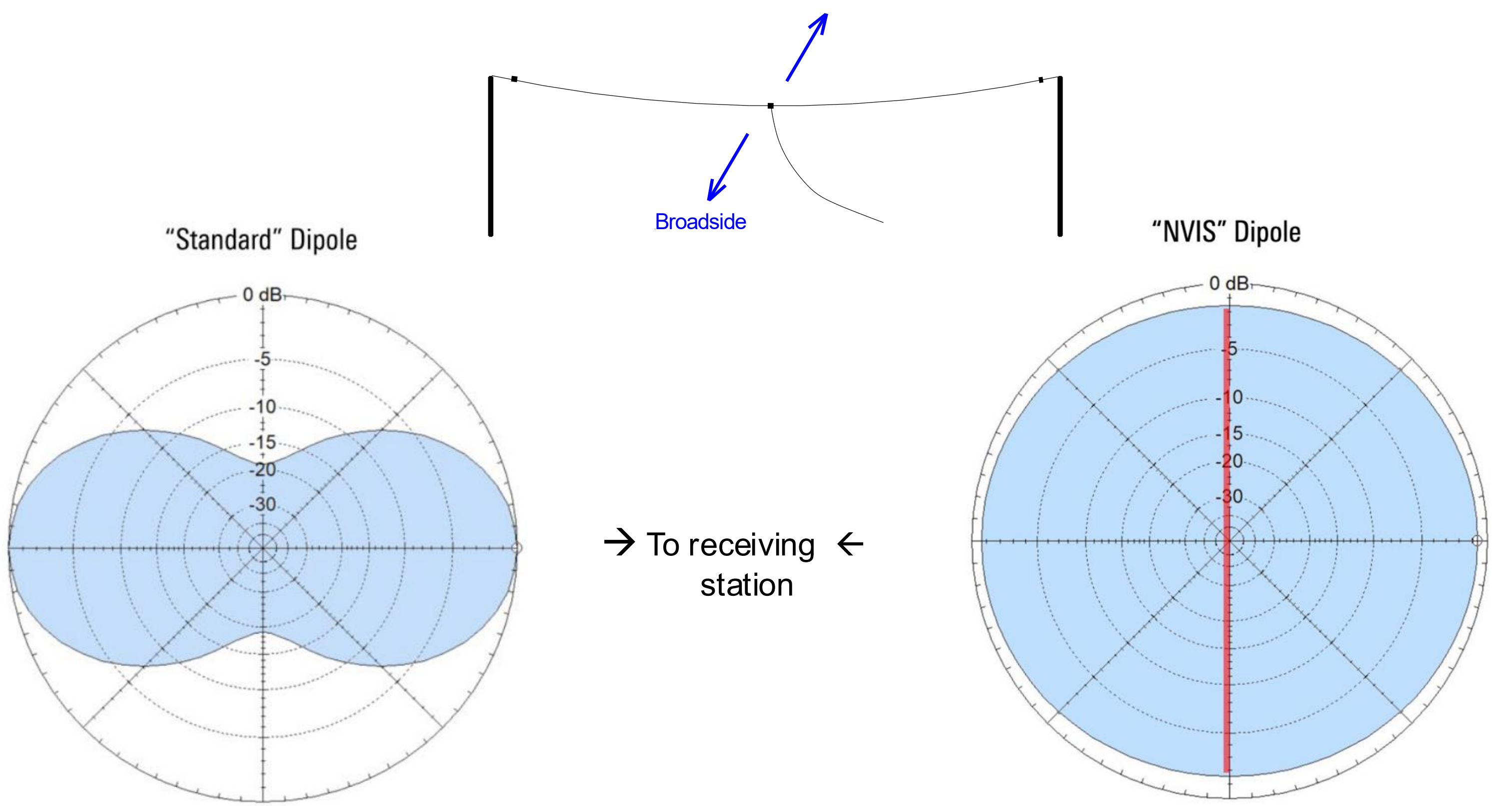

Author




Off Grid Ham

- Adding a Reflector element below a NVIS antenna enhances the antenna's vertical radiation pattern 2 to 3 db compared to a NVIS dipole 1/4 wavelength above ground
- The -3db angle for this 2 element antenna is about 60º with a single hop distance of around 200 miles
- The 2 element configuration is strictly a NVIS antenna
- A simple dipole 1/4 wavelength above ground is a more general purpose antenna
- It providing good NVIS capabilities, nearly as good as the 2 element antenna
- In addition it provides longer distance multi-hop communications with hops of up to 600 miles

# Omnidirectional



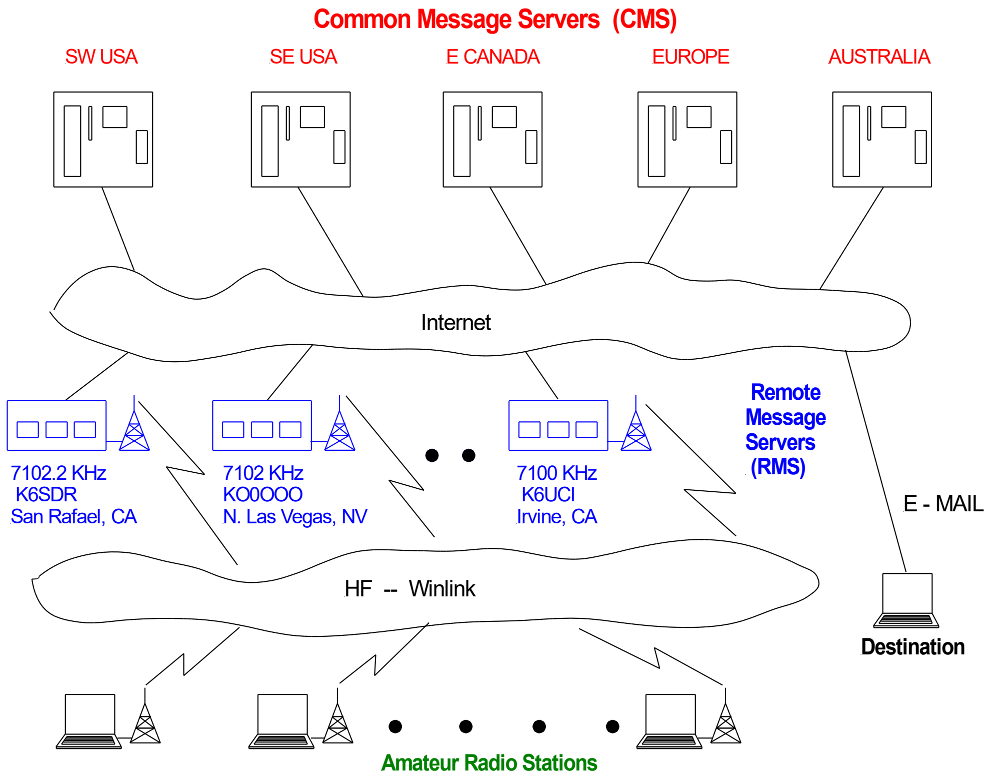

www.rars.org

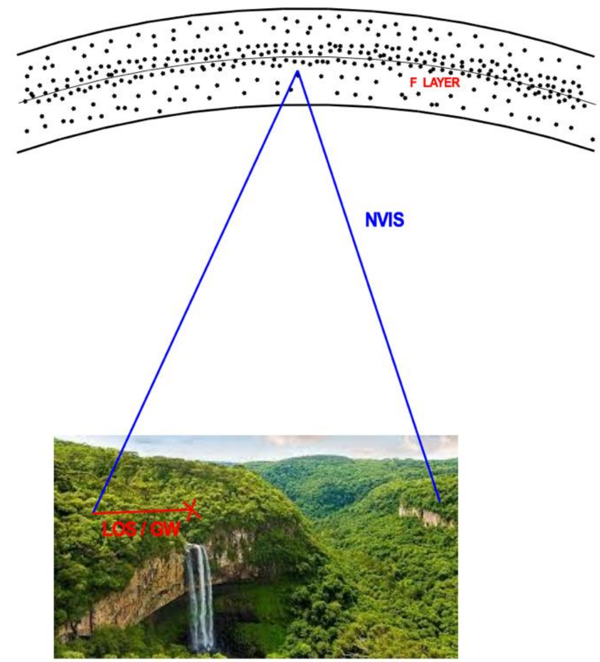
- A standard dipole for long distance HF communications is oriented so that the direction of the intended receiving station is broadside to the antenna
- However, because of its close proximity to ground, a NVIS antenna is omnidirectional
- Consequently, the orientation of a NVIS antenna relative to the receiving station is unimportant

# Author's Current RV Configured For NVIS


- We tend to think of NVIS antennas being large ----- but they don't have to be
- Author's 40 meter NVIS antenna constructed from two 8 ft "Ham Stick" antennas connected together in a shortened dipole configuration approximately 15 ft above ground

# NVIS Extensively Used For Winlink Communications




- **Why?** (1) NVIS low power requirements (2) Few terrain problems (3) Minimal D-Layer absorption (4) No skip zone (5) fewer fading problems (6) Fewer multi-path interference problems (7) No backscatter (8) Uses easy to install omnidirectional antennas
- Selecting NVIS Winlink stations is very easy: simply select RMS stations within a range of 300 miles that are operating on 40 meters during the day and 80 meters at night
- **Point-to-Point Winlink is extremely important** when digital NVIS communications is required and the Winlink RMS structure is not available or appropriate

# That’s It Folks


HF Radio is fun

Plus

It provides communications when all else fails !