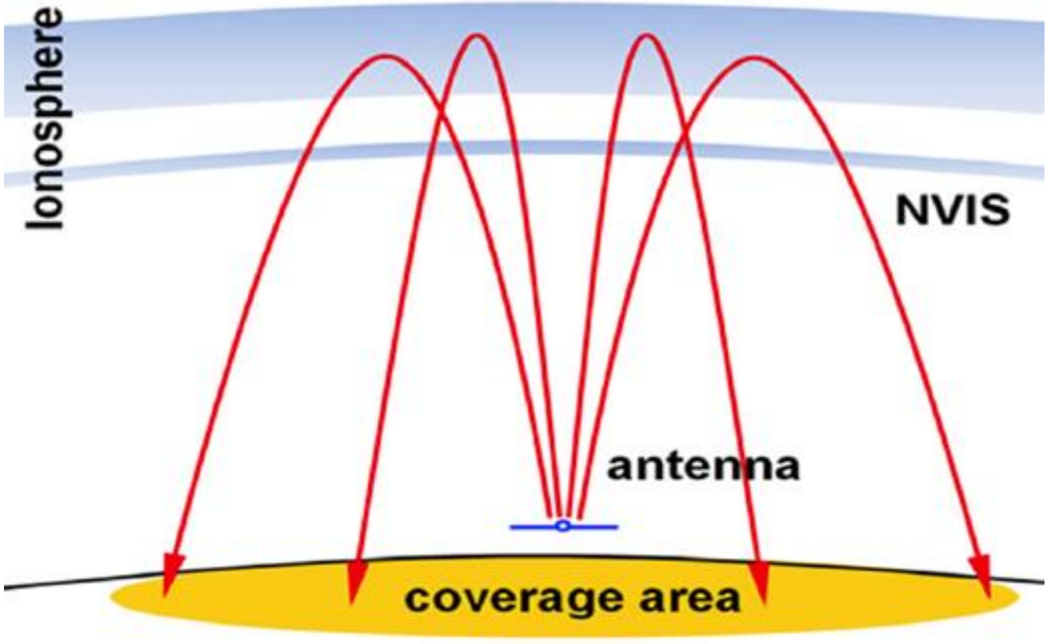
Near Vertical Incidence Skywave Radio Wave Propagation

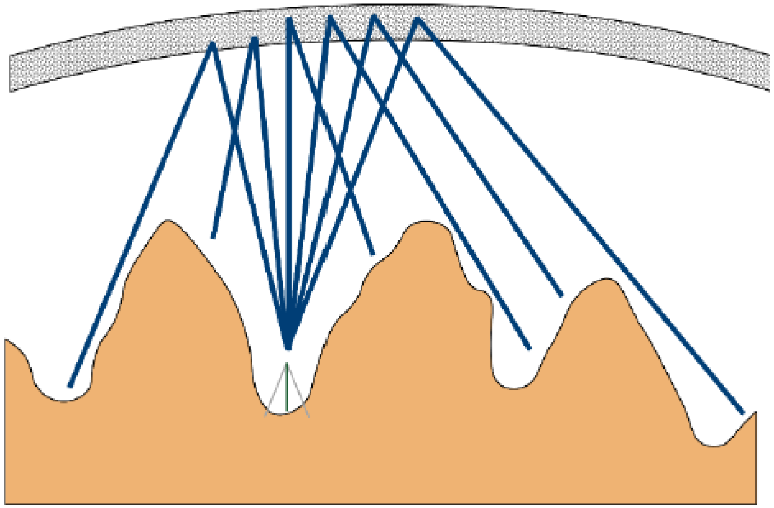
Dennis Silage K3DS



NVIS Radio Wave Propagation

- ***Near Vertical Incidence Skywave*** (NVIS) is a special case of HF skywave propagation that enables both skip zone coverage as well as coverage in challenging terrain, where groundwave or low angle skywave signals might be blocked.

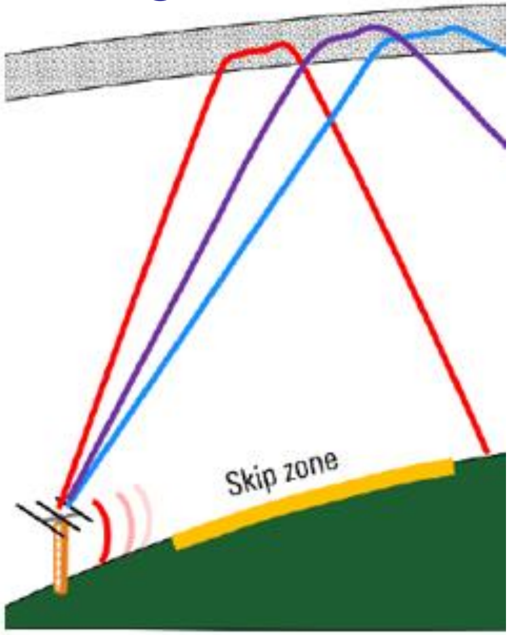
- NVIS is implemented using an antenna with a ***very high take-off angle***, typically 75° or more, with transmission taking place on lower HF frequencies to ensure that signals are returned from the ionosphere.



NVIS Radio Wave Propagation

- This local or regional coverage makes NVIS very well-suited for applications that require communications in challenging terrain, such as during disaster relief operation.

- However, for normal QSOs, NVIS allows good communication to local or regional stations where propagation from conventional antennas would be blocked by terrain or would be in the ***skip zone*** to the intended recipient.

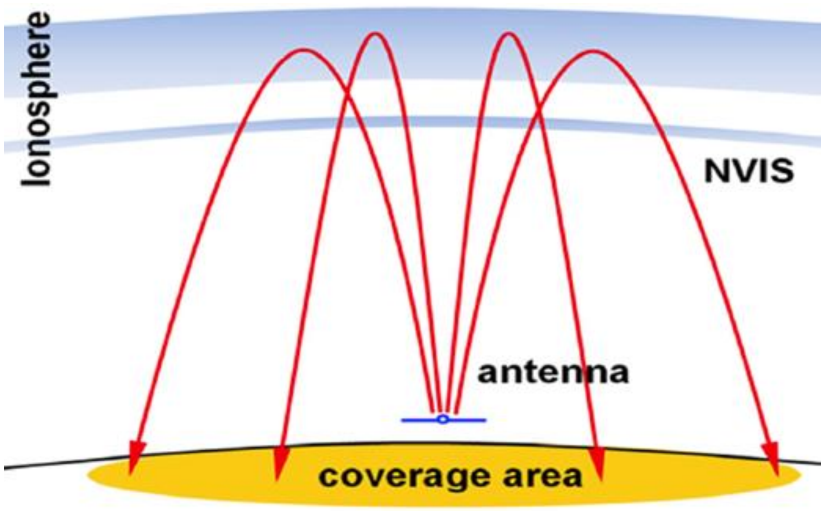


NVIS Radio Wave Propagation - Advantages

- NVIS has several technical advantages.

- The first of these is that NVIS is ***more resistant to fading*** than traditional skywave propagation and provides a more constant signal level.

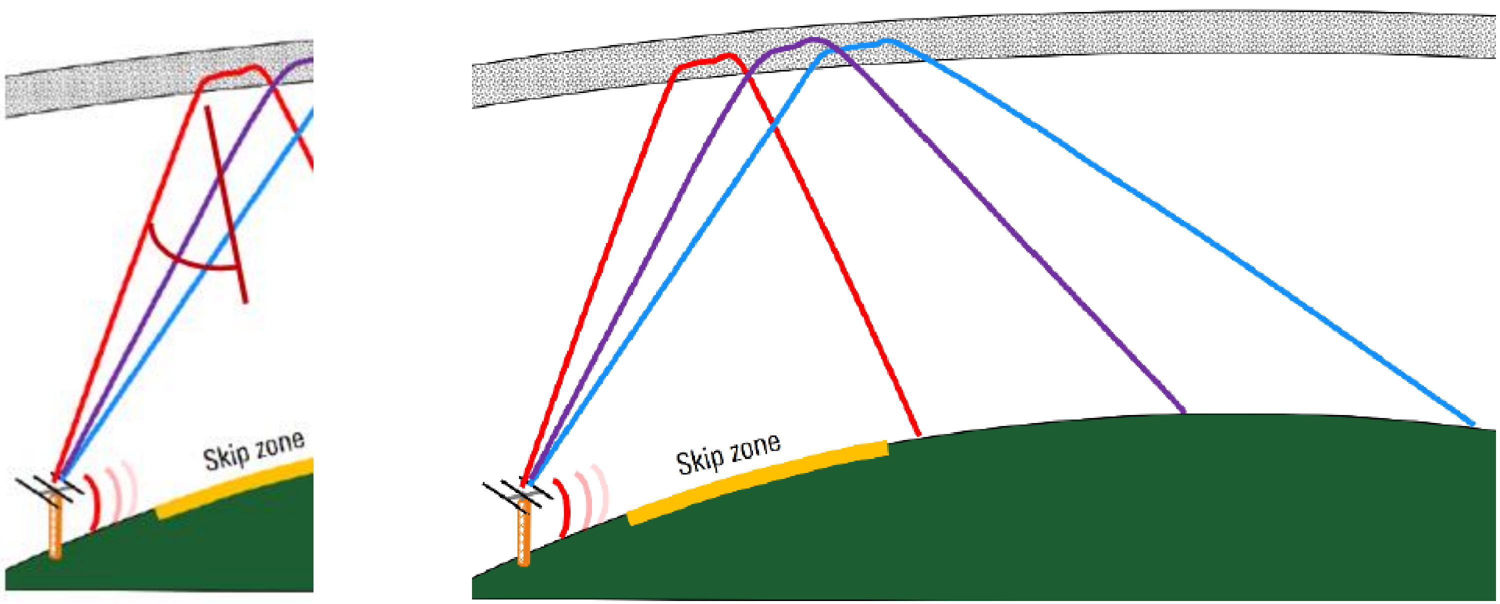
- The near vertical ***incidence angle*** of NVIS means a shorter path through the ionosphere and therefore less absorption.



NVIS Radio Wave Propagation

- The ***incident angle*** is the angle at which a signal reaches the ionosphere.

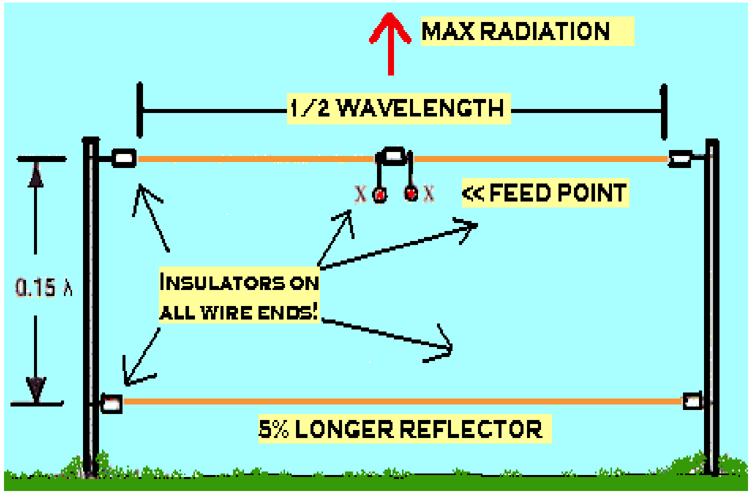
- The incidence angle plays an important role in determining how far an MF/HF radio wave skywave signal will propagate.

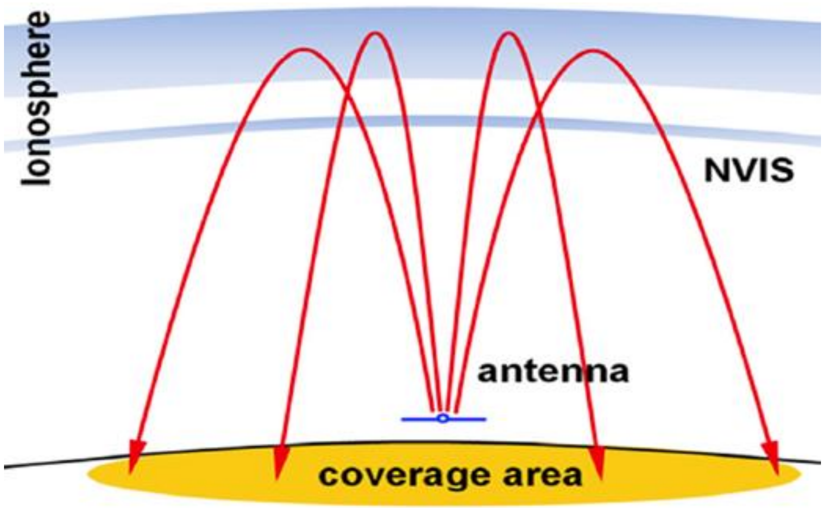


NVIS Radio Wave Propagation - Advantages

- The shorter overall path length reduces the attenuation between transmitter and receiver.

- Attenuation of the signal due to terrain or obstructions is minimal because there is line of sight propagation between the transmitter and the ionosphere as well as between the ionosphere and the receiver.

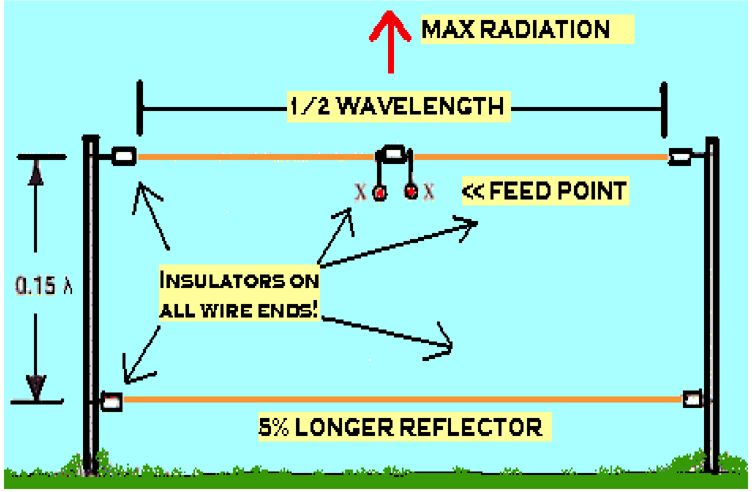


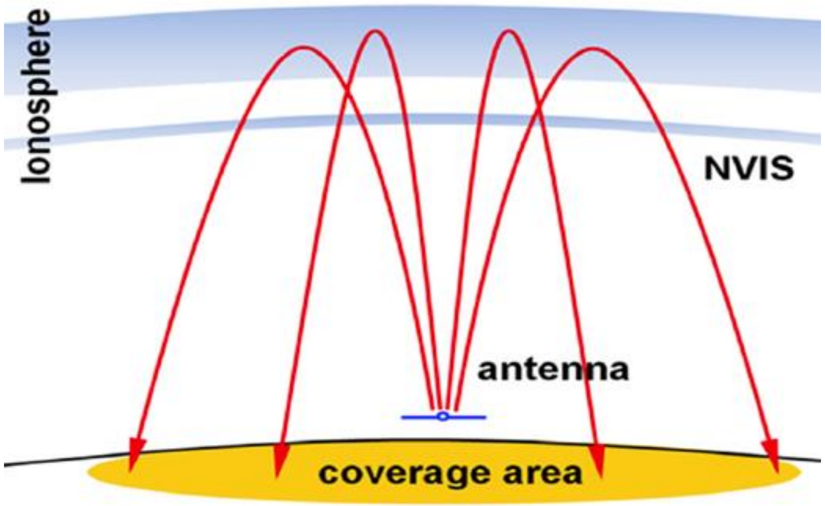


NVIS Radio Wave Propagation - Advantages

- This line of sight propagation also helps to reduce fading due to multipath because a near-vertical take-off angle reduces the opportunities for the signal to be reflected from objects.

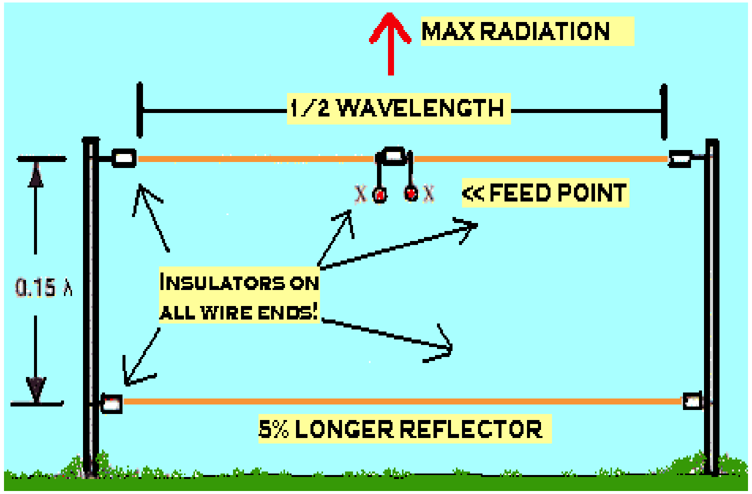
- The combination of these factors means that NVIS works well at relatively low transmit power levels.

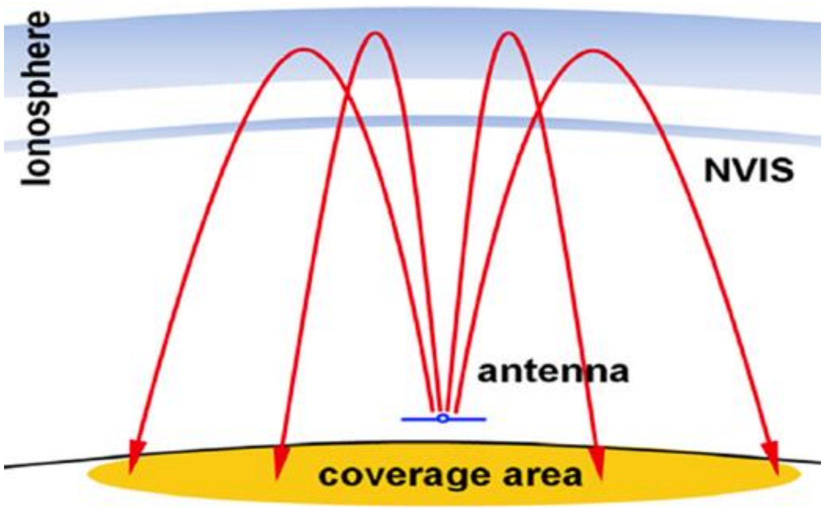




NVIS Radio Wave Propagation - Advantages

- The roughly omnidirectional coverage pattern created by a NVIS antenna makes antenna orientation or azimuth less critical in providing coverage to the desired locations and facilitates operations such as local or regional HF nets.



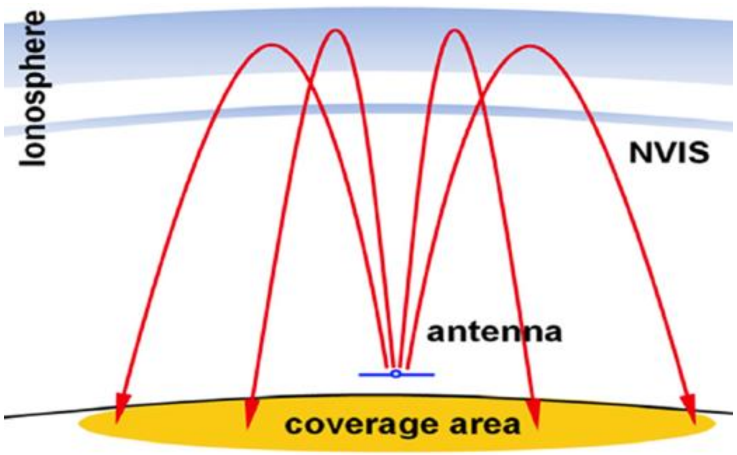


NVIS Radio Wave Propagation - Disadvantages

- There are, however, also some disadvantages when using NVIS.

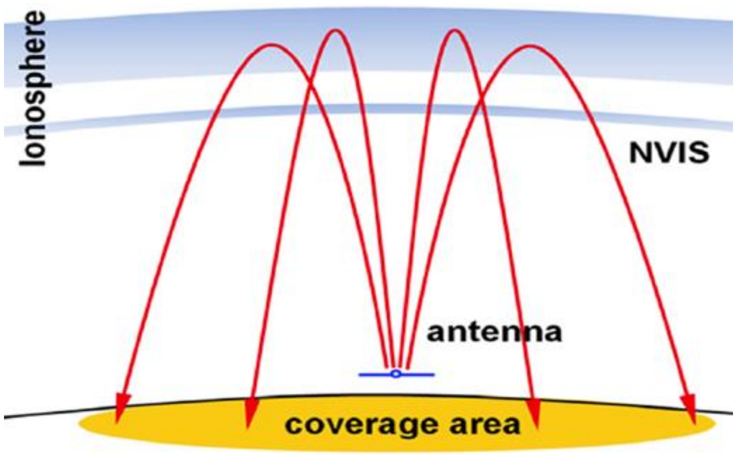
- One of the most important of these is that NVIS only works at lower HF frequencies, usually below 20 meters.

- The nature of NVIS antenna patterns and propagation limits the maximum range of NVIS to the low hundreds of miles, compared to the thousands of miles that can be achieved low-incidence angle skywave propagation.



NVIS Radio Wave Propagation - Disadvantages

- Optimum results require the use of NVIS antennas on both the transmit and receive stations.
- An additional potential disadvantage of using NVIS is that both atmospheric and man-made noise levels tend to be higher at the lower frequencies below 20 meters that are used in NVIS-based HF communications.

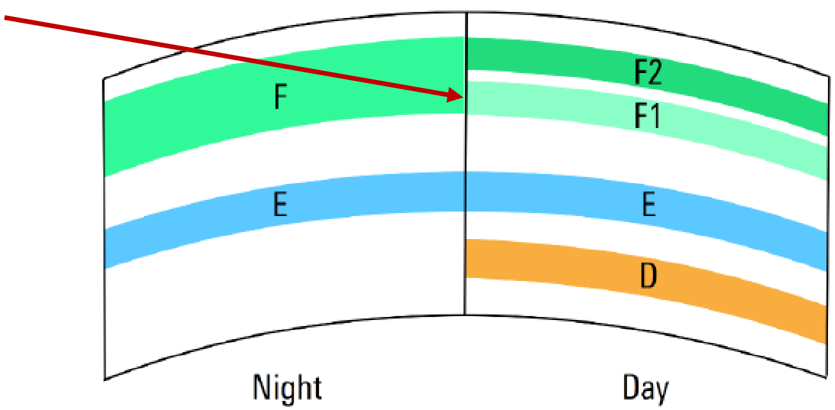


NVIS Radio Wave Propagation

- To make effective use of NVIS, frequencies that are low enough to be refracted by the ***F-layer*** of the ionosphere when arriving with a very high incidence angle are used.

- During daylight hours, the F-layer splits into two sub-layers: F1 and F2, which then merge back into a single layer again at night.

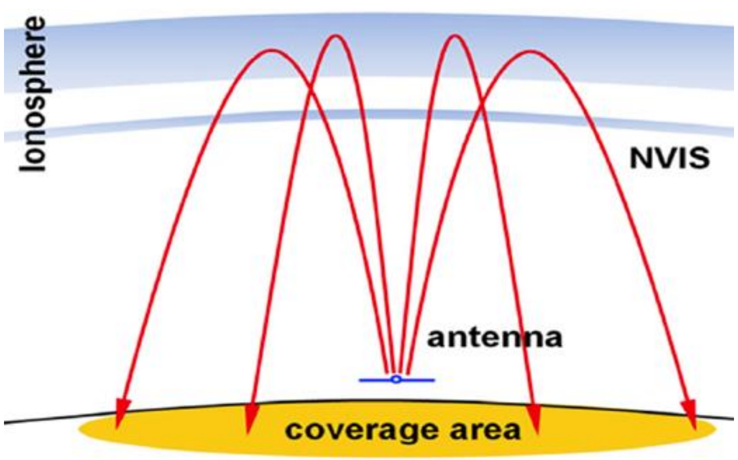
- The lower F1-layer primarily supports communications during ***daylight hours***.

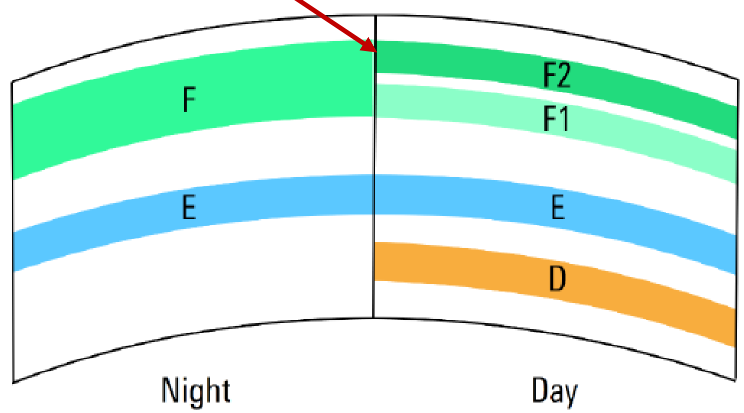


NVIS Radio Wave Propagation

- The F2-layer, on the other hand, is present more or less ***around the clock***.

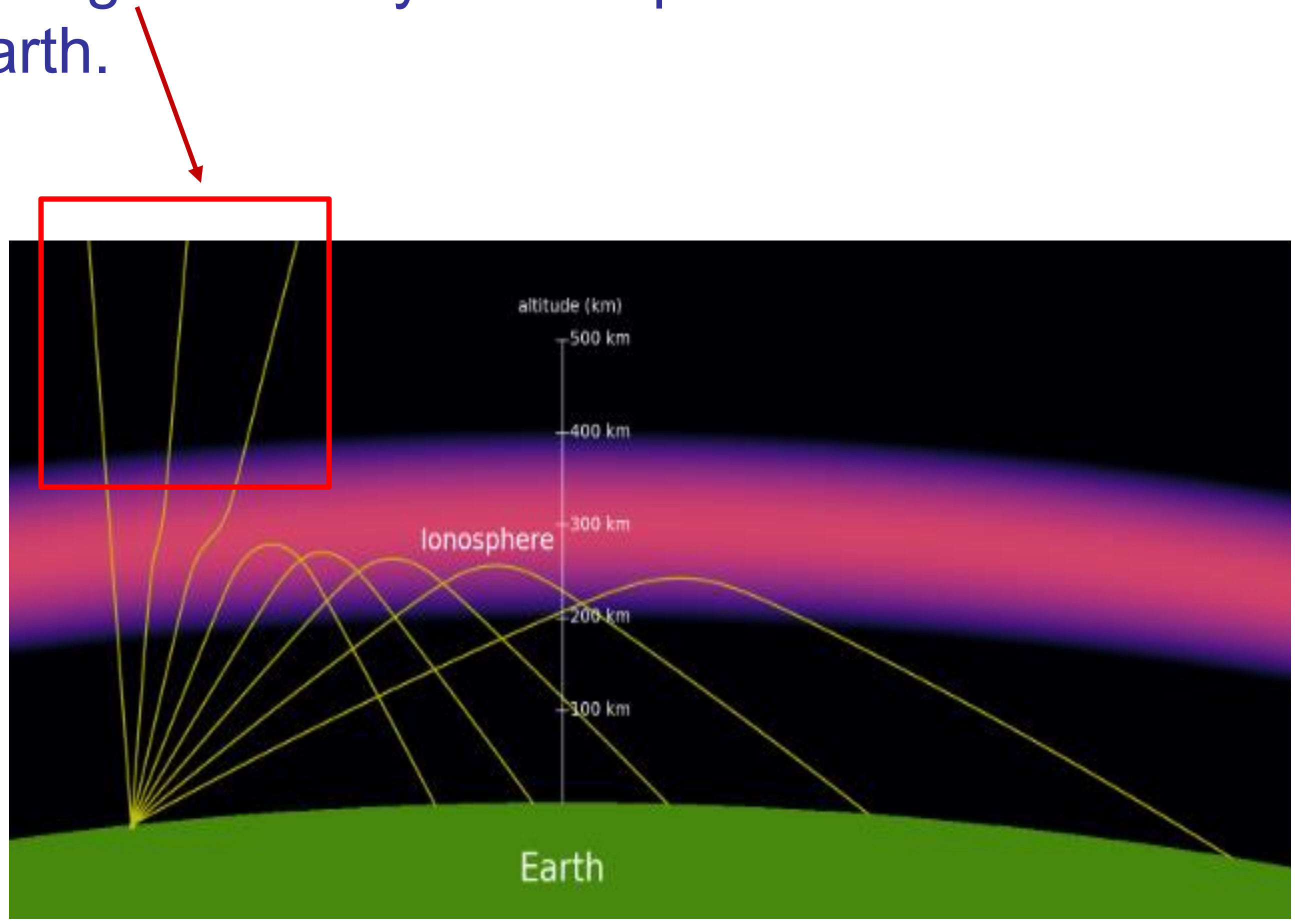
- The F2-layer has the highest altitude and the highest ionization of all the layers and is therefore responsible for the vast majority of long-distance HF radio wave communications.





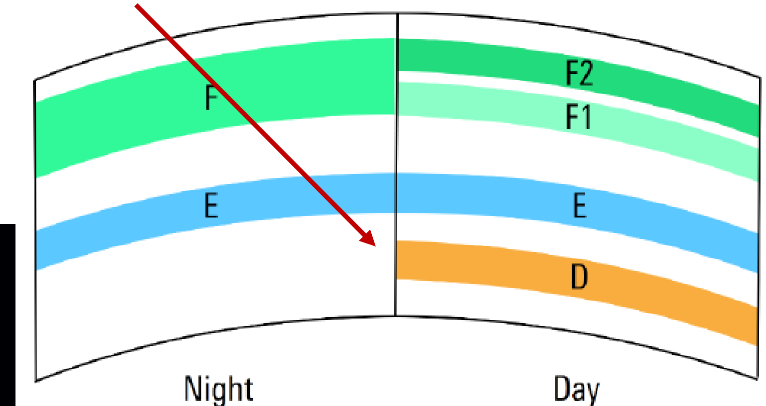
NVIS Radio Wave Propagation

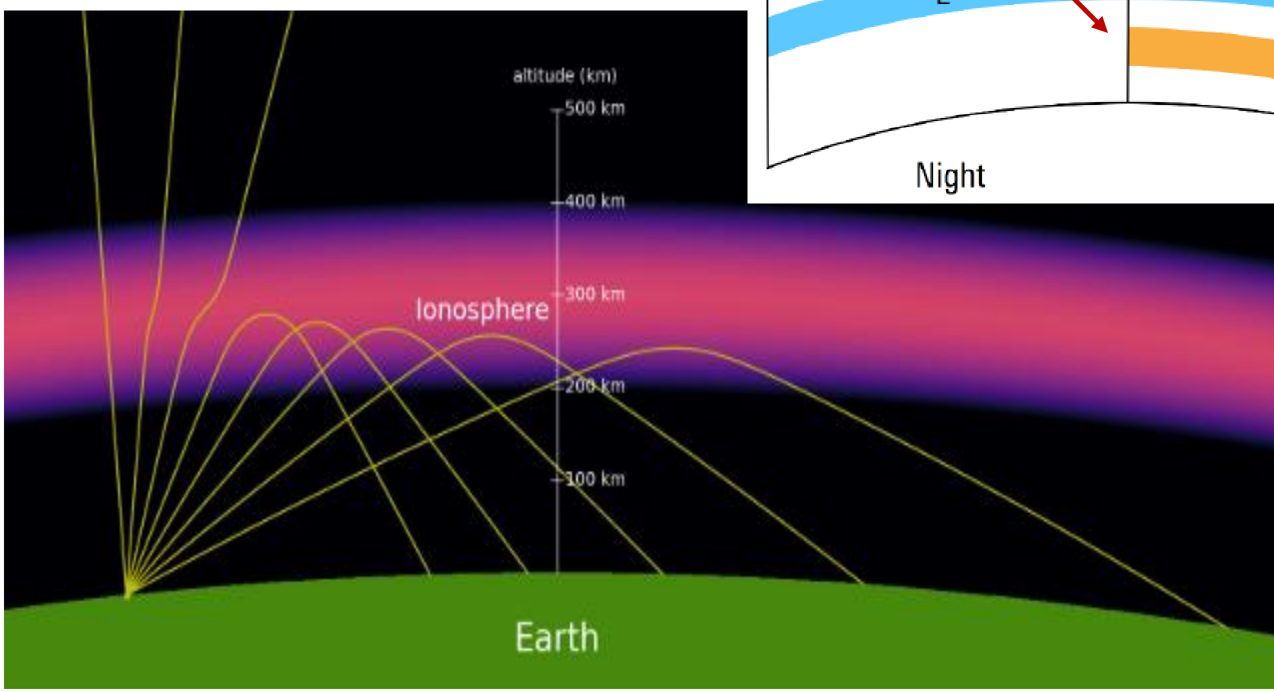
- Signals with too high of a frequency will simply pass through the F-layer into space and will not be returned to Earth.



NVIS Radio Wave Propagation

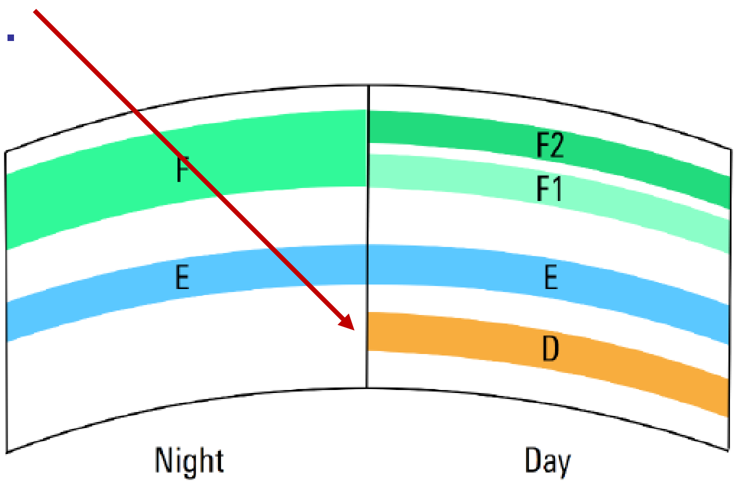
- NVIS also requires the use of frequencies that are high enough to avoid excessive ***D-layer*** attenuation.





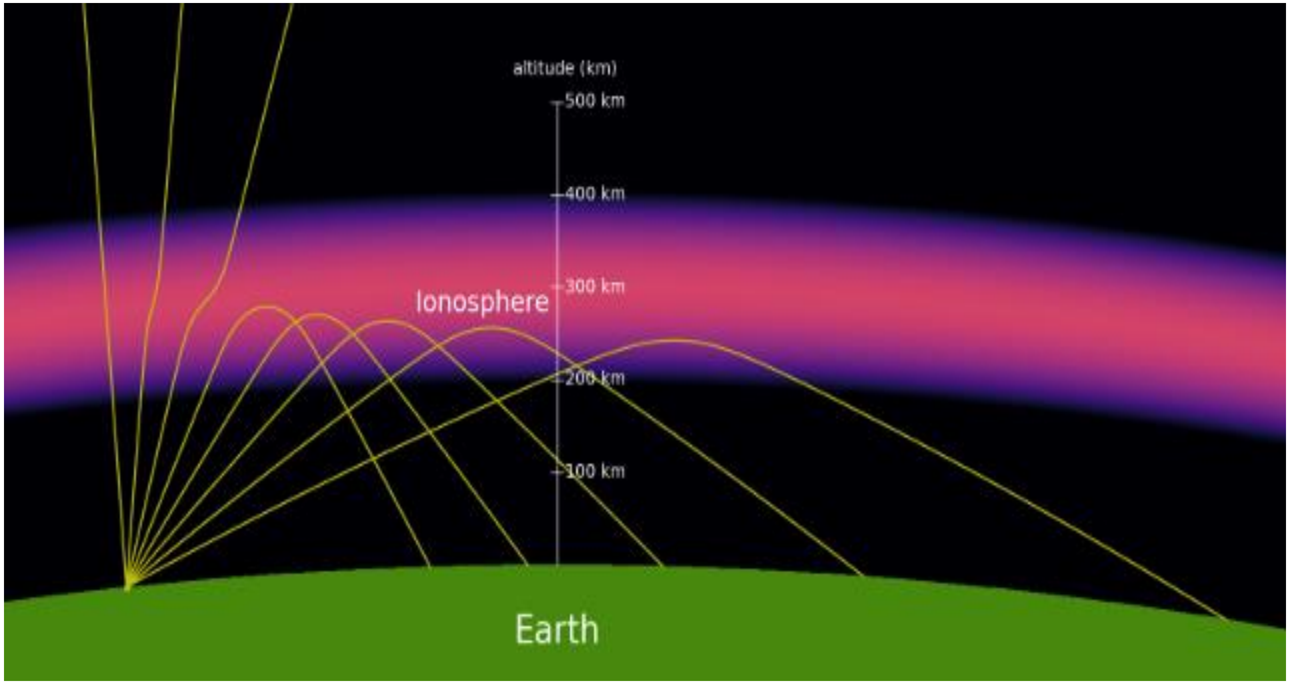
NVIS Radio Wave Propagation

- The D-layer only exists during ***daytime*** hours and disappears at night.
- Although the D-layer is ionized by solar radiation, the density of free electrons in the D-layer is too low to effectively ***refract*** radio waves.
- The D-layer ***inhibits*** communications because it acts as an absorber of radio waves.



NVIS Radio Wave Propagation

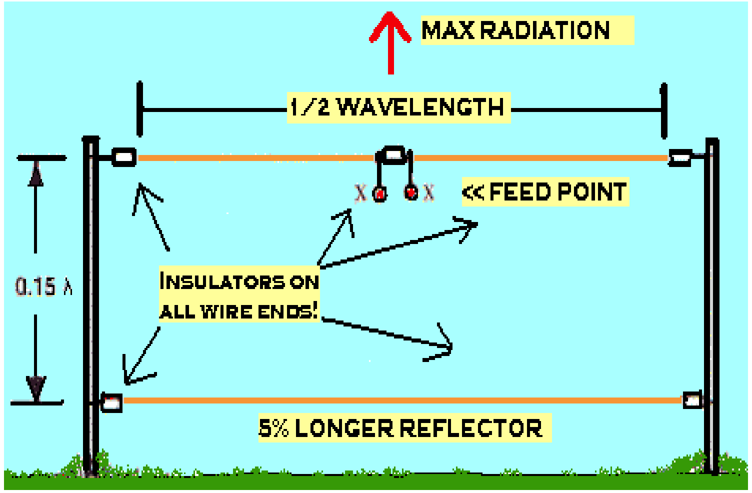
- In order to balance out these two somewhat conflicting requirements, NVIS operation uses frequencies in the range of approximately 2 to 10 MHz (80, 60 and 40 meter bands).

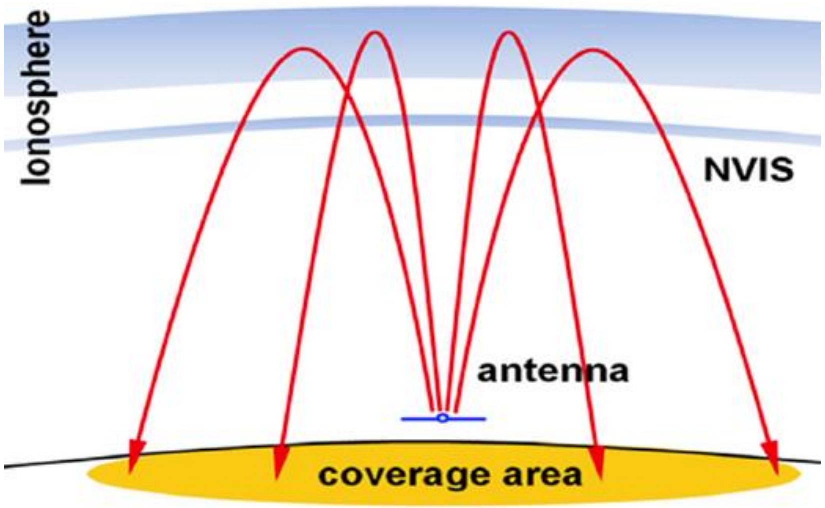


NVIS Radio Wave Propagation

- However, like all other skywave propagation, the maximum frequencies depend on the ***level of atmospheric ionization***

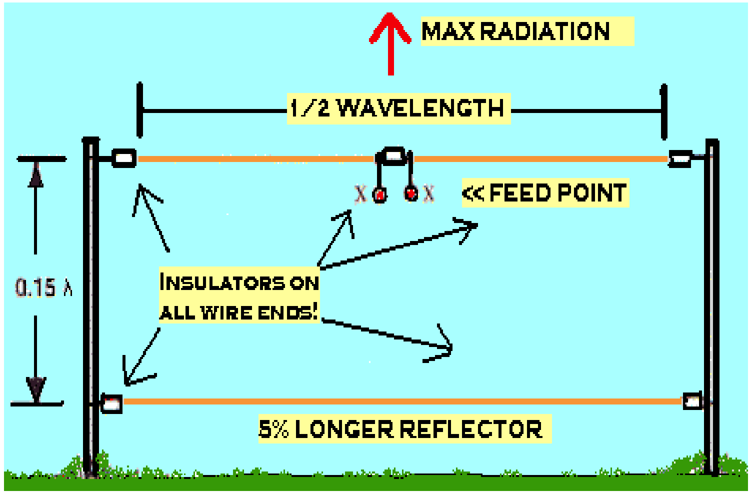
- This in turn depends on factors such as sunspot number or solar flux index, the time of day, the season, and any abnormal solar events.

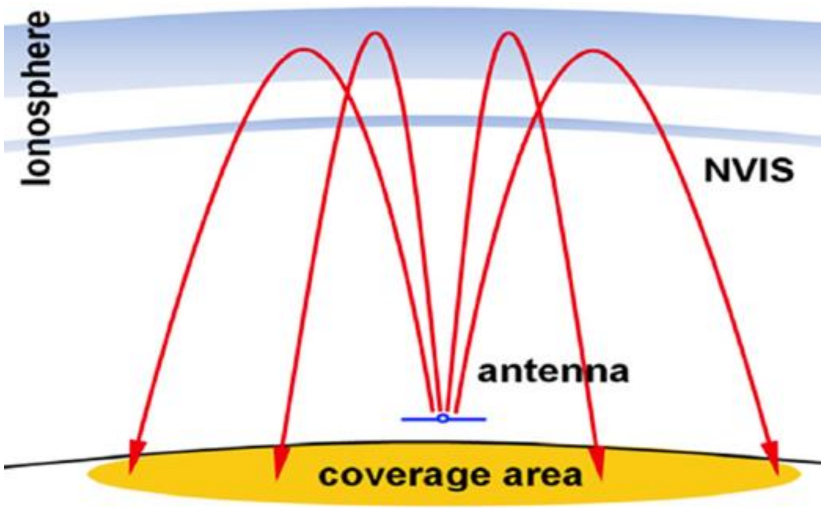




NVIS Radio Wave Propagation

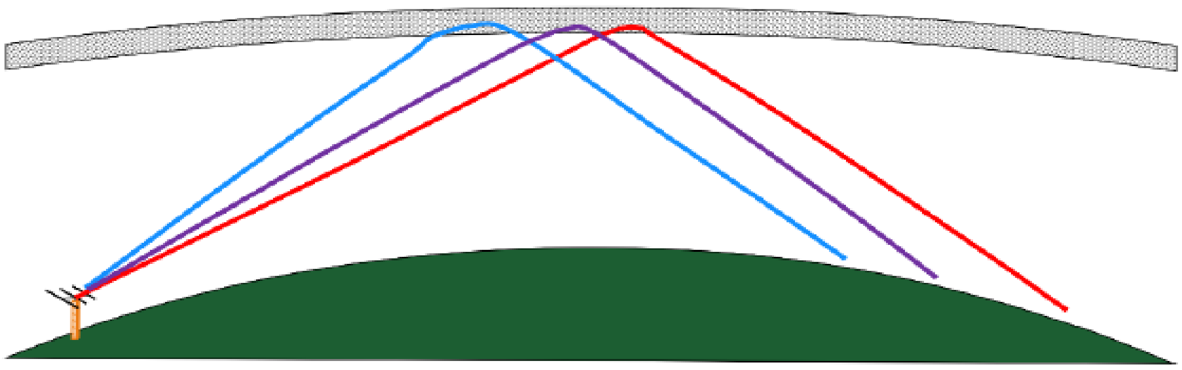
- For example, during solar minima, the maximum usable frequency for NVIS may only be 6 to 8 MHz.
- NVIS usually utilizes 80 meters during the day and 80, 60 and 40 meters at night, but this can vary significantly.





NVIS Radio Wave Propagation

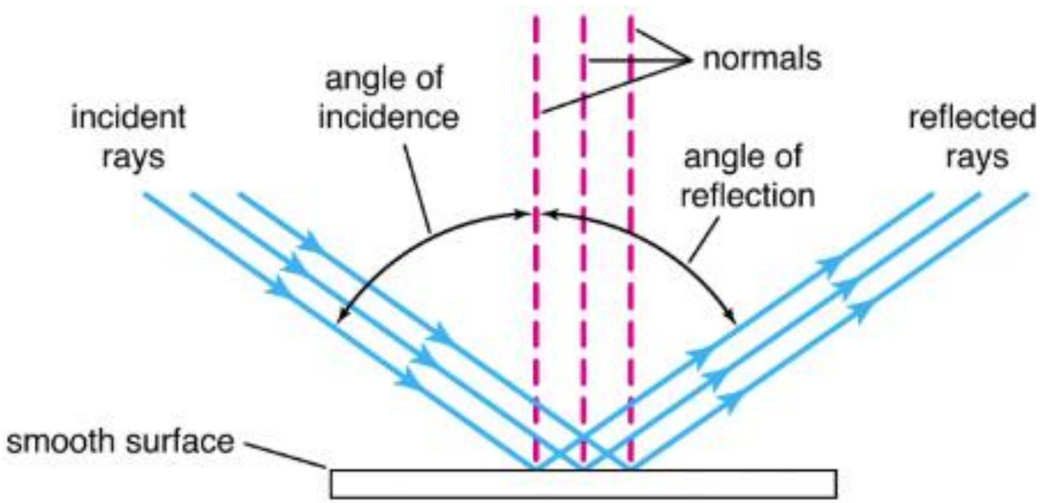
- Most antennas intended for HF skywave communications are designed to have a low take-off or radiation angle.
- This lower take-off angle causes a lower angle of incidence with the ionosphere and hence longer distances due to lower ***refraction angles***.
- Ionospheric ***refraction*** is the ***bending*** of the propagating radio wave.



NVIS Radio Wave Propagation

- Recall that the ionosphere does not ***reflect*** MF/HF radio signals but rather ***refracts*** them.

- ***Reflection*** occurs when a propagating radio wave interacts with a conducting surface, such as with a *parabolic dish*.

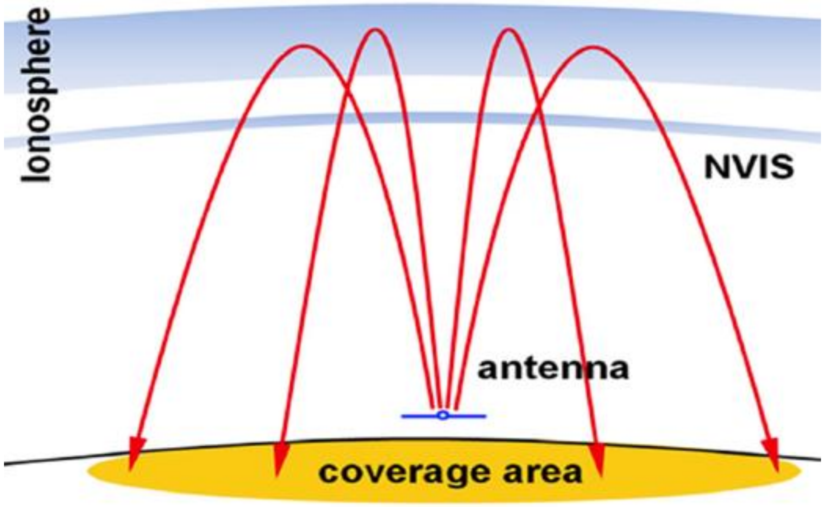


NVIS Radio Wave Propagation

- In traditional, long-distance applications of HF skywave, an antenna that sends too much energy vertically is sometimes unflatteringly referred to as a *cloud warmer*.

- On the other hand, NVIS antennas are specifically designed and installed to have a high radiation angle, typically 75° or higher.

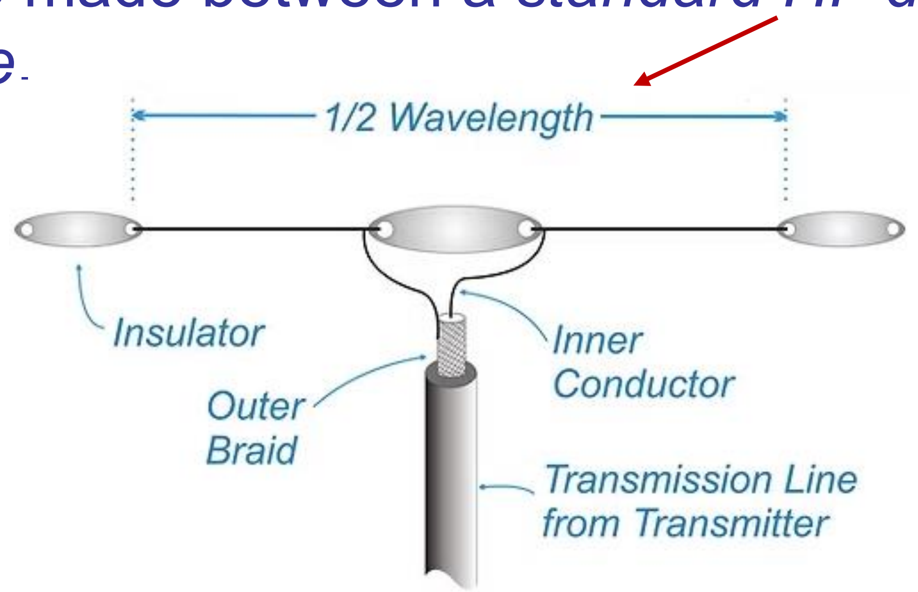
- The majority of RF power is *going up* instead of *going out*.



NVIS Radio Wave Propagation

- One of the best ways to understand the difference between traditional, low-incidence angle skywave antennas and NVIS antennas is to compare antenna patterns.

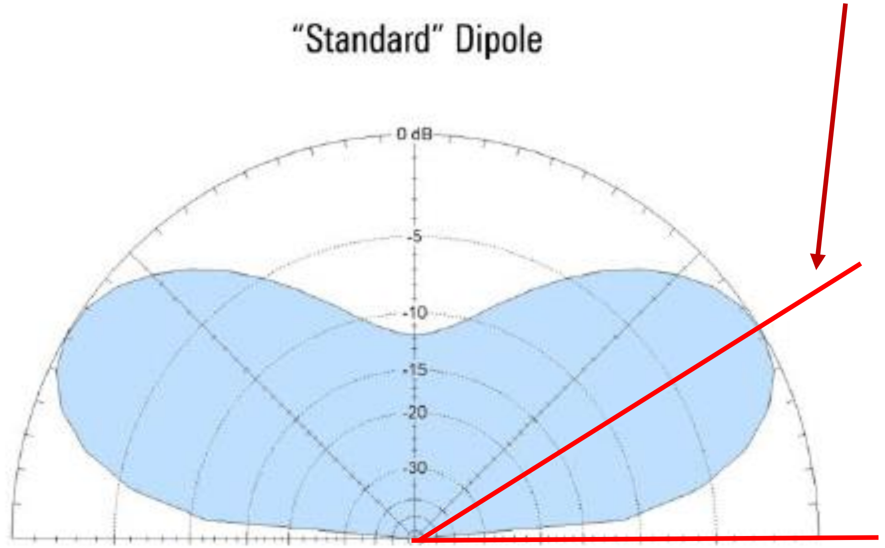
- Since NVIS can be implemented as a dipole, a useful comparison can be made between a *standard HF dipole* and an *NVIS dipole*.



NVIS Radio Wave Propagation

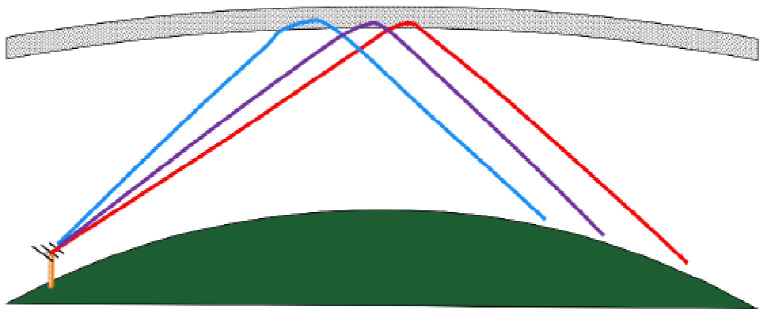
- A *standard HF dipole* is usually mounted at a height that produces a relatively low elevation angle.

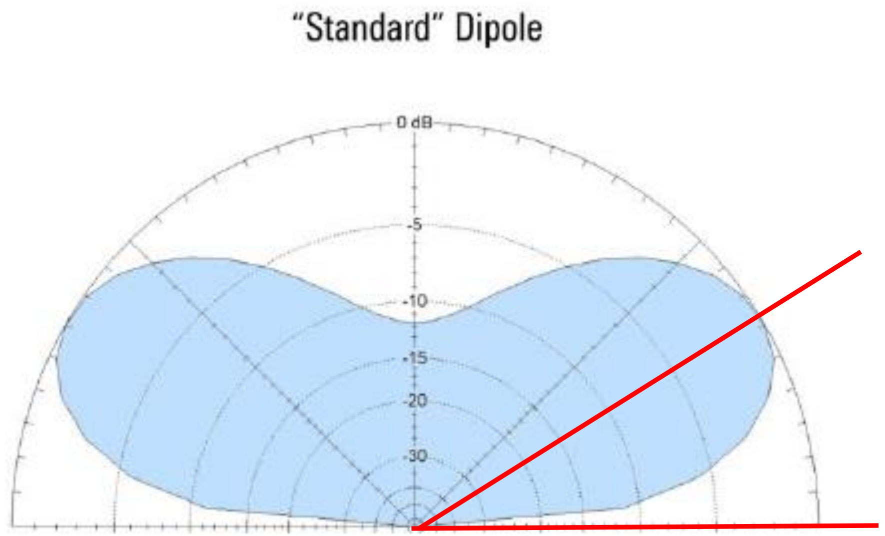
- The relationship between elevation angle and antenna height can be somewhat complex, but generally speaking, the higher a dipole is mounted above the ground, the lower its elevation or *take-off* angle.



NVIS Radio Wave Propagation

- A lower elevation angle works well for long-distance HF skywave communications because greater distances can be achieved when the transmitted signal is incident to the ionosphere at lower angles.

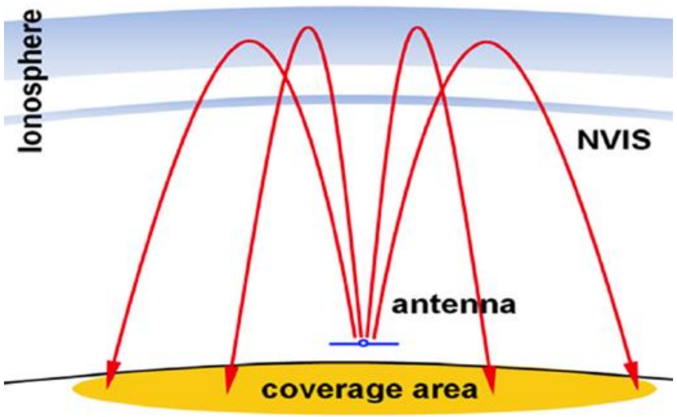




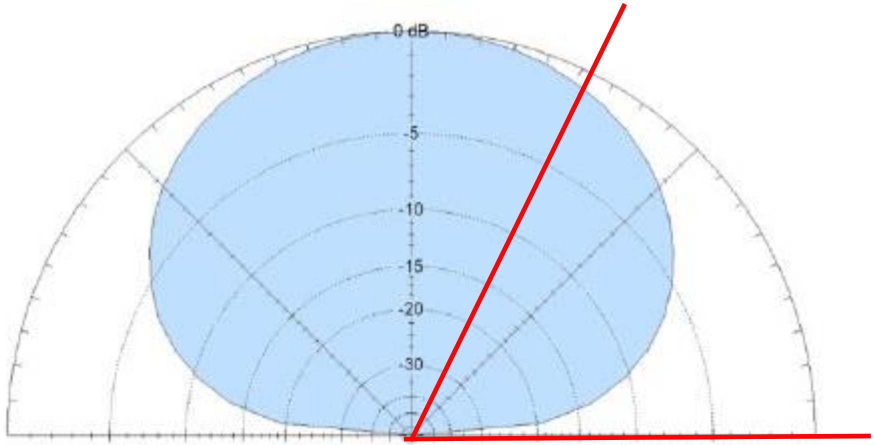
NVIS Radio Wave Propagation

- An *NVIS dipole* is characterized by a much higher or more vertical elevation pattern.

- The primary method of creating this type of vertical radiation pattern is by moving the dipole closer to the ground.



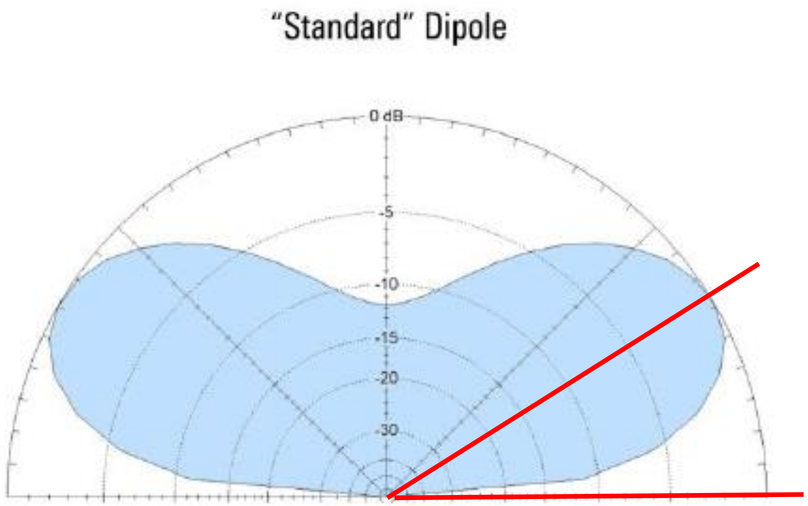
"NVIS" Dipole

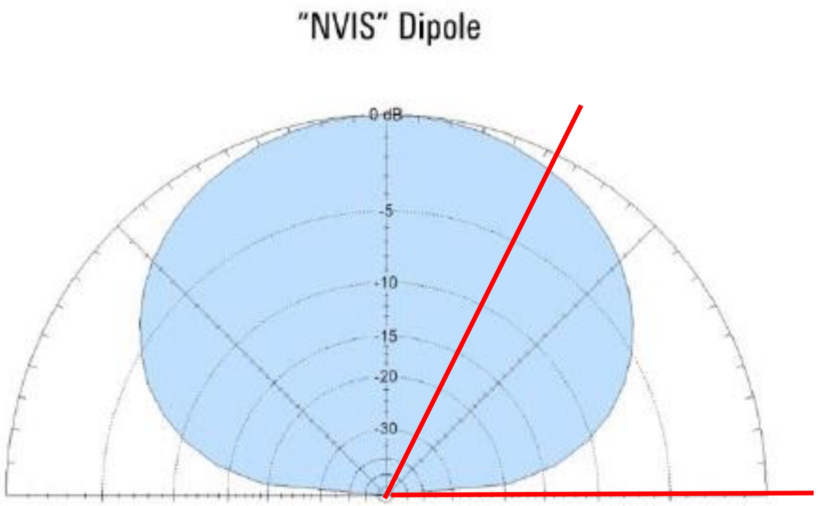


NVIS Radio Wave Propagation

- *Elevation patte*rns show the distribution of energy, or gain, in the ***vertical plane*** around the antenna.

- An elevation pattern comparison of a standard HF dipole and an NVIS antenna demonstrates the difference.

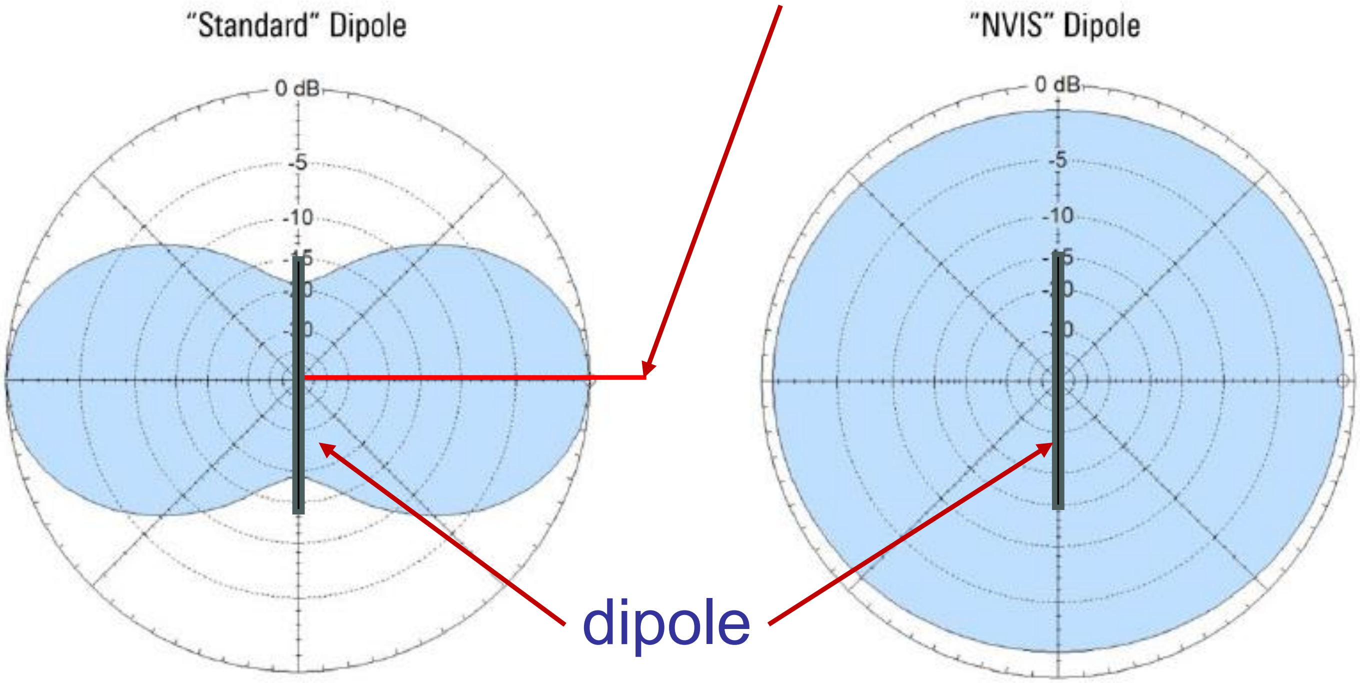




NVIS Radio Wave Propagation

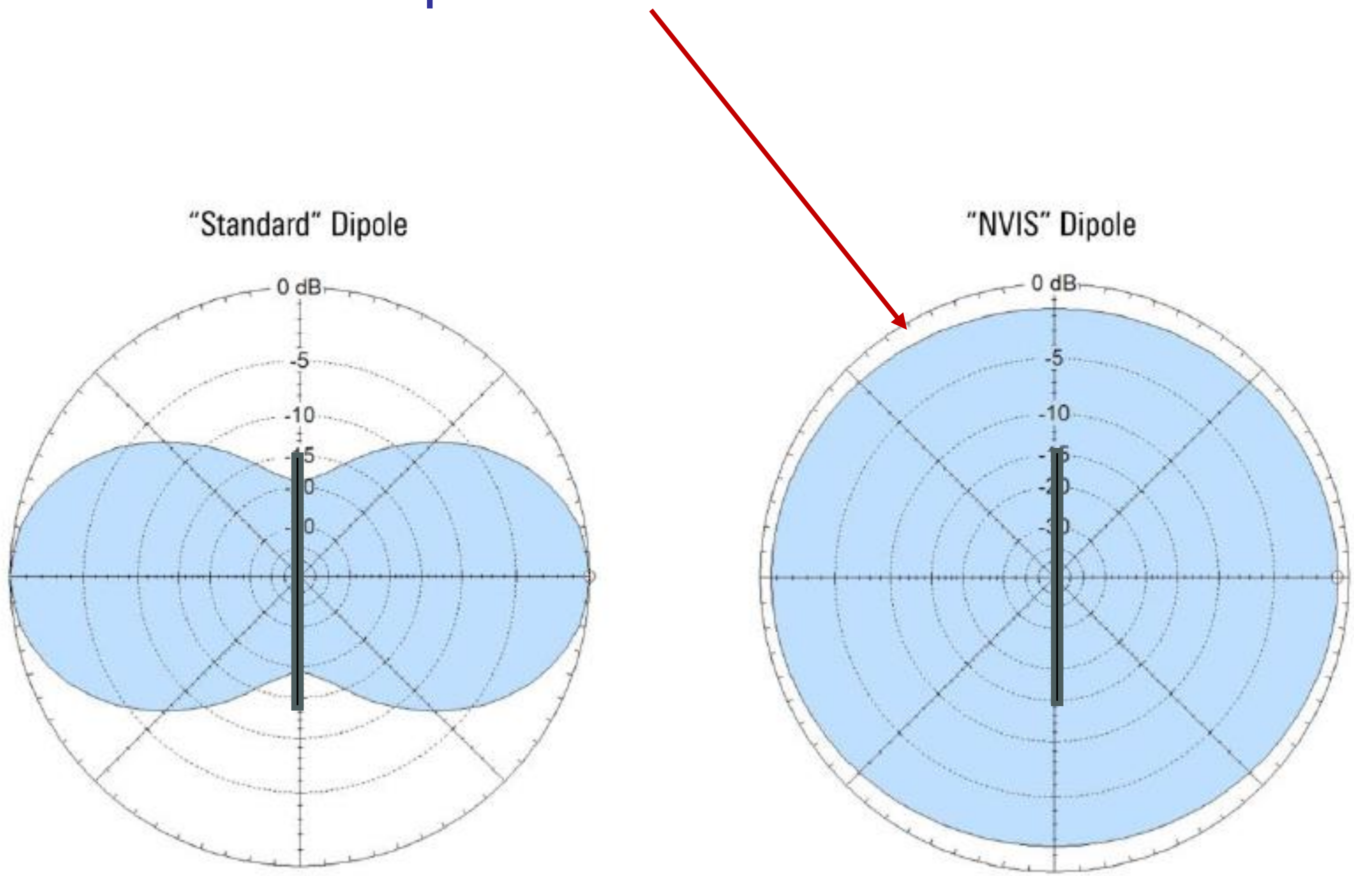
- *Azimuth patterns* show the distribution of energy, or gain, in the ***horizontal plane*** around the antenna.

- A standard HF dipole has a directional pattern, with the majority of gain being *broadside* to the antenna.



NVIS Radio Wave Propagation

- In a typical NVIS antenna, the azimuth pattern is roughly *omnidirectional*, meaning that the orientation of the NVIS antenna is less important.

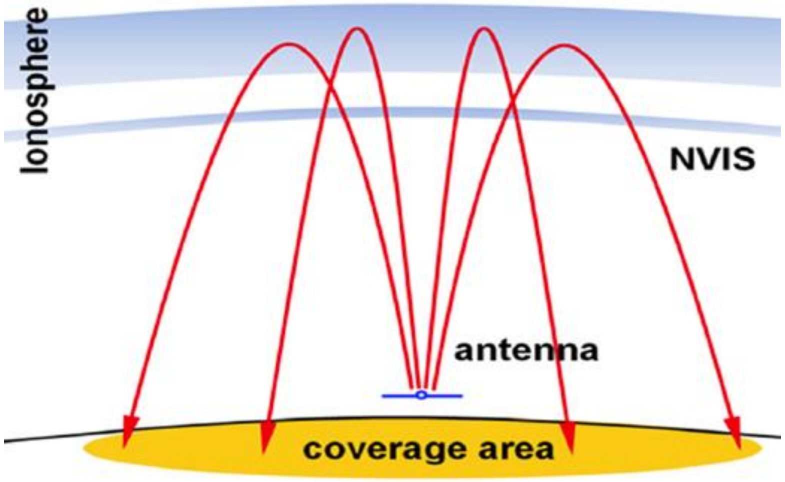


NVIS Radio Wave Propagation

- NVIS describes a certain type of antenna, or more precisely, a certain radiation pattern and elevation angle produced by an antenna.

- There are however many different types of antennas that can be used or adapted to produce the high incidence angle NVIS antenna pattern.

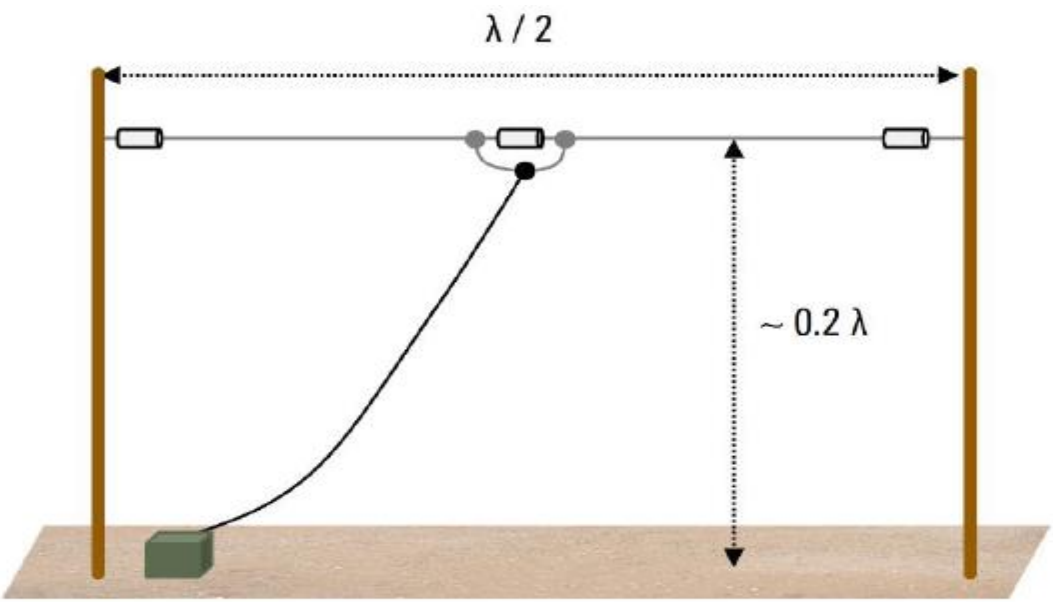
- Some of the most frequently used types of NVIS antennas are *dipoles* and *inverted Vees.*



NVIS Radio Wave Propagation

- The standard half-wavelength dipole can be used for NVIS applications.

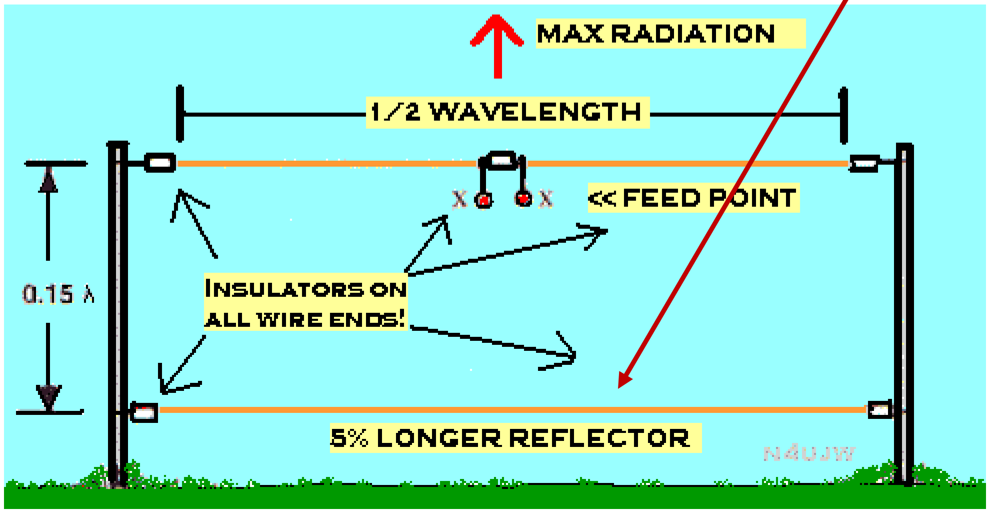
- In order to create a more vertical radiation angle, a NVIS dipole needs to be much lower, usually approximately 0.2 wavelengths above the ground. Generally speaking, the lower the active element, the higher the radiation angle.



NVIS Radio Wave Propagation

- To some extent, the optimum antenna height is also a function of ground conductivity: the higher the ground conductivity, the lower the optimal height.

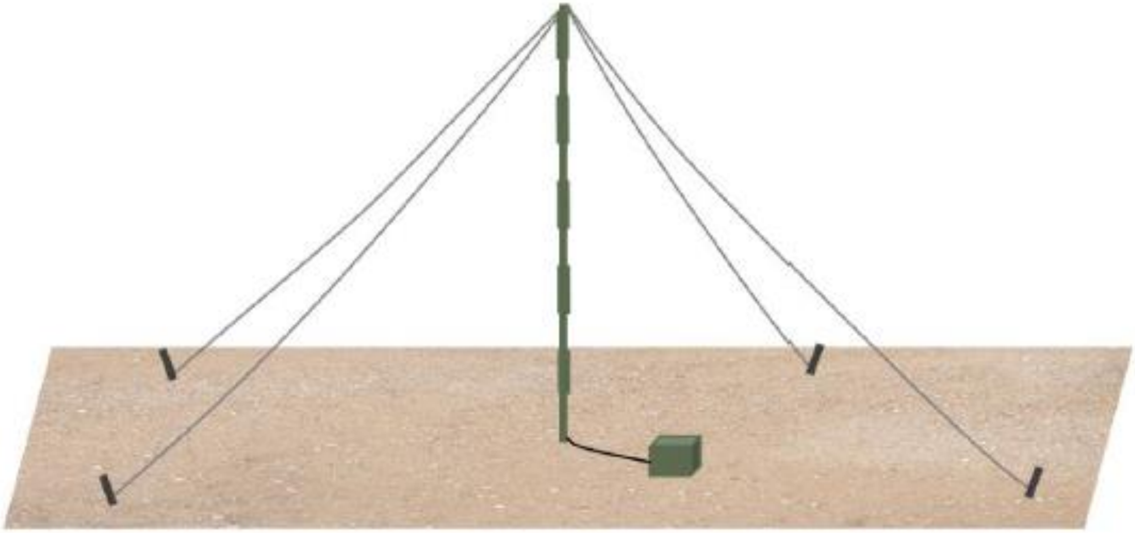
- Because of this, the use of an optional *reflector element* has sometimes been recommended, for example, when the soil has very low conductivity such as sand or rock, or if the dipole is high above the ground.



NVIS Radio Wave Propagation

- An inverted Vee is a variant of the horizontal dipole, with the center of the dipole being supported by a vertical mast and the ends being close to or near the ground.

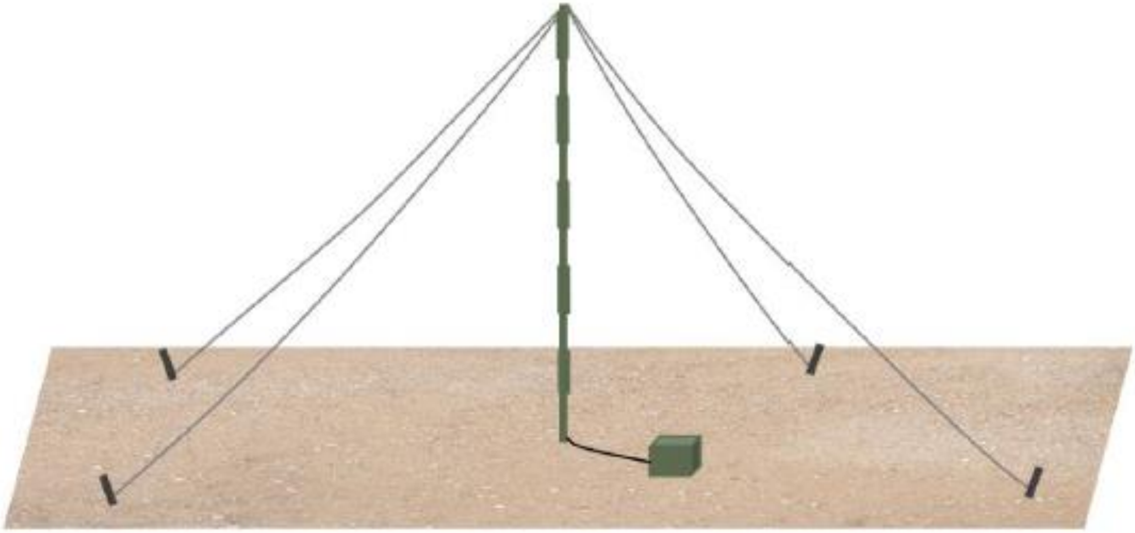
- A very common implementation of the inverted Vee in NVIS uses *two dipoles*, often positioned at roughly right angles to each other.



NVIS Radio Wave Propagation

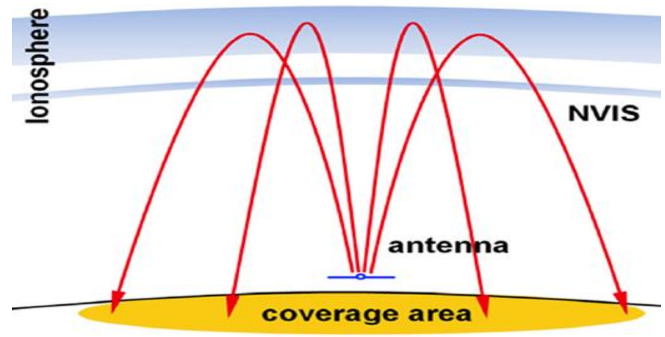
- This arrangement is sometimes referred to as a *turnstile antenna* and is easy to erect.

- Using a pair of dipoles helps to overcome polarization related fading.



NVIS Radio Wave Propagation

- NVIS antennas on 80 and 40 meters facilitate local and regional *rag chews*.




R.C.C.

QST

This is to Certify that WB2LGJ

is a member-station of the

Rag Chewers' Club

and is entitled to all the privileges, prerogatives, rights, favors, glory, rank, fame, notoriety, popularity and honor of membership in that worthy organization.

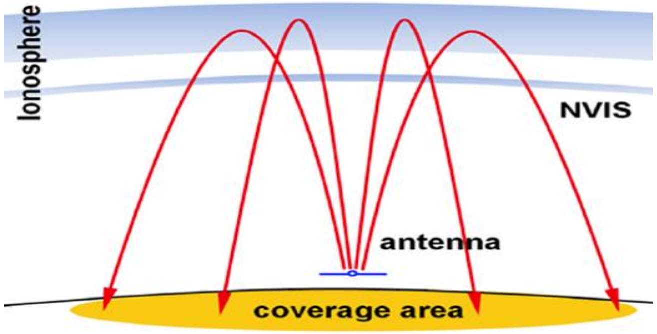
In accepting this certificate the member agrees to abide by the published rules of the organization.

The Old Sock

CHIEF RAG CHEWER

NVIS Radio Wave Propagation

- NVIS antennas on 80 and 40 meters facilitate local and regional net operation.



- *Phil-Mont Mobile Radio Club Net*
  Sunday 10:00 AM 3.993 LSB +/- QRM
- *Eastern PA Emergency Phone & Traffic Net*
  Daily 5:00 PM 3.918 LSB
- *Pennsylvania Fone Net*
  Monday 8:00 PM 3.920 Friday 9:00 PM 3.910 LSB
- *East Coast Amateur Radio Service*
  Monday-Friday 7:30 AM Saturday/Sunday 8:00 AM
  7.255 LSB

Near Vertical Incidence Skywave Radio Wave Propagation

Dennis Silage K3DS

Questions, Comments?