

# Radio Wave Behavior



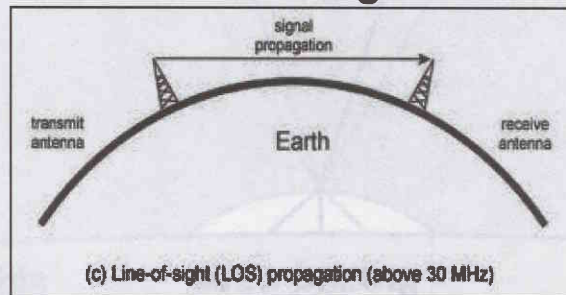
VS.



85 mpg

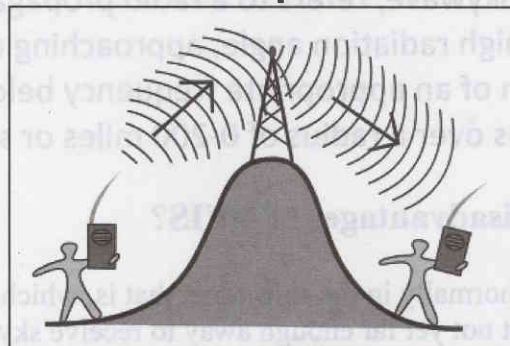
0.6 mpg

## Line of Sight

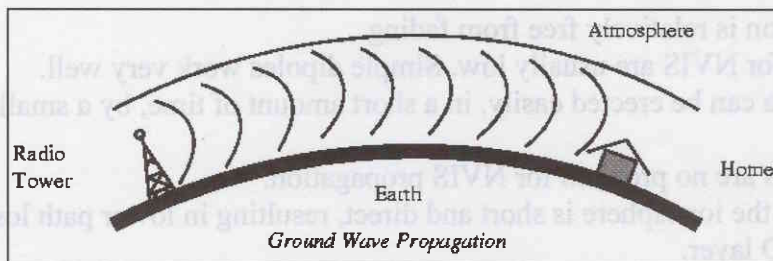


Range 5 to 7 Miles with a hand held radio

## VHF Repeater



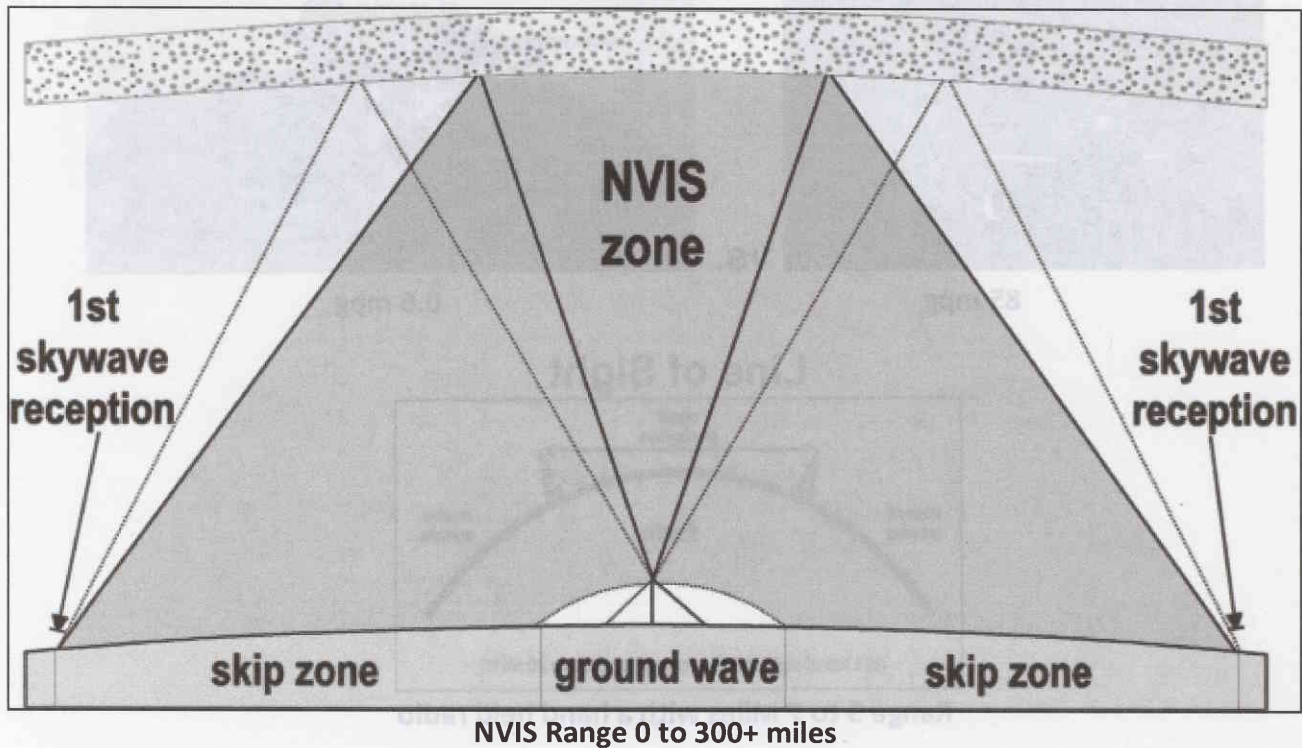
Range 50+ Miles with a hand held radio



**Ground Wave Propagation** follows the curvature of the Earth. Ground Waves have carrier frequencies up to 2 MHz. AM radio is an example of Ground Wave Propagation.

# Radio Wave Behavior

## NVIS



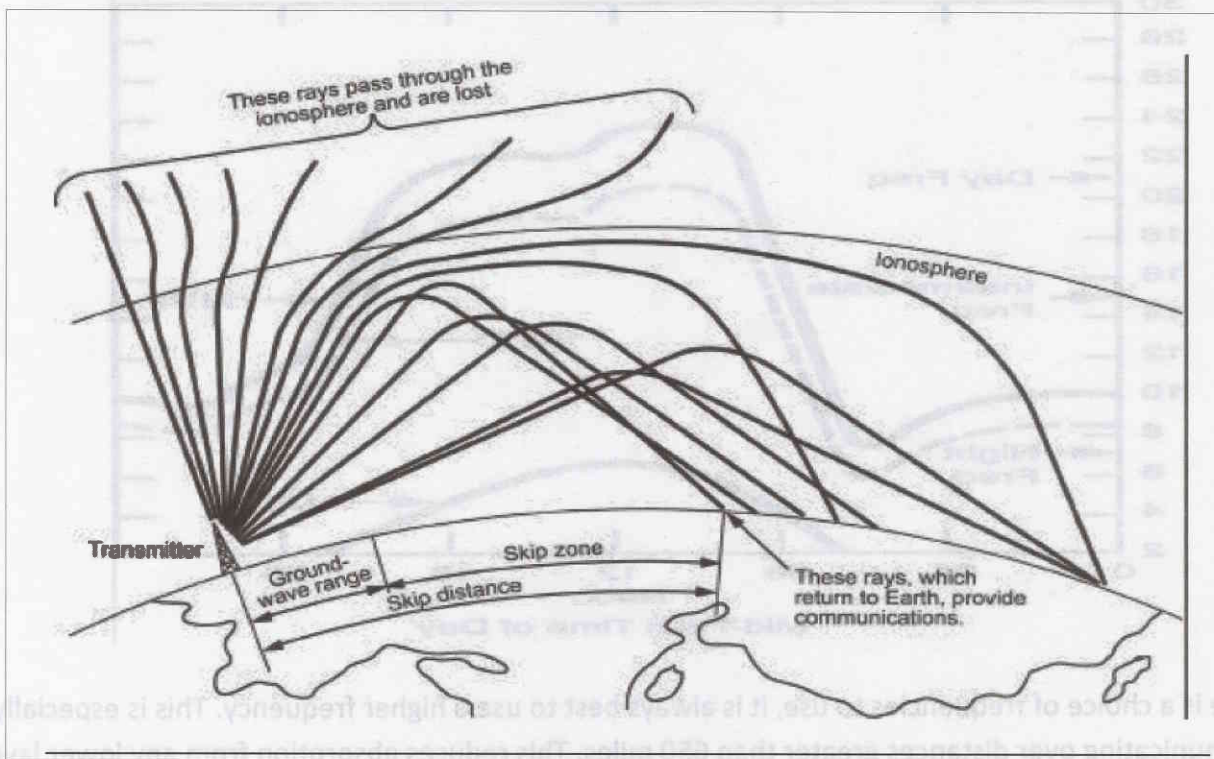
NVIS, or Near Vertical Incidence Skywave, refers to a radio propagation mode which involves the use of antennas with a very high radiation angle, approaching or reaching 90 degrees (straight up), along with selection of an appropriate frequency below the critical frequency, to establish reliable communications over a radius of 0-200 miles or so, give or take 100 miles.

### What are the advantages and disadvantages of NVIS?

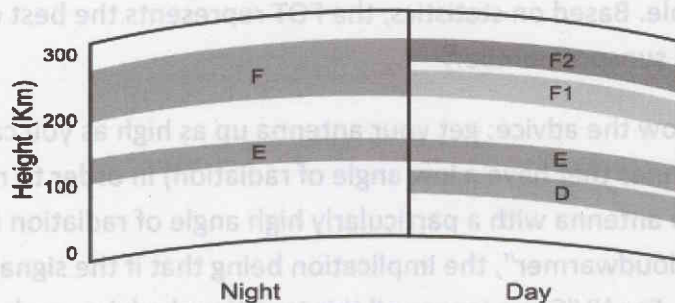
- NVIS covers the area which is normally in the skip zone, that is, which is normally too far away to receive groundwave signals, but not yet far enough away to receive skywaves reflected from the ionosphere. **NVIS requires no infrastructure such as repeaters or satellites.**
- Two stations employing NVIS techniques can establish reliable communications without the support of any third party.
- Pure NVIS propagation is relatively free from fading.
- Antennas optimized for NVIS are usually low. Simple dipoles work very well.
- A good NVIS antenna can be erected easily, in a short amount of time, by a small team (or just one person).
- Low areas and valleys are no problem for NVIS propagation.
- The path to and from the ionosphere is short and direct, resulting in lower path losses due to factors such as absorption by the D layer.
- NVIS techniques can dramatically reduce noise and interference, resulting in an improved signal/noise ratio.
- With its improved signal/noise ratio and low path loss, NVIS works well with low power.

## Radio Wave Behavior

### MAXIMUM USABLE FREQUENCY (MUF) AND LOWEST USABLE FREQUENCIES (LUF)



An important concept associated with sky wave propagation is called the maximum usable frequency (MUF). The MUF is the highest frequency at which a radio wave will reflect from an ionospheric layer for a given elevation or propagation path. Frequencies higher than the MUF will penetrate the layer and escape into space.

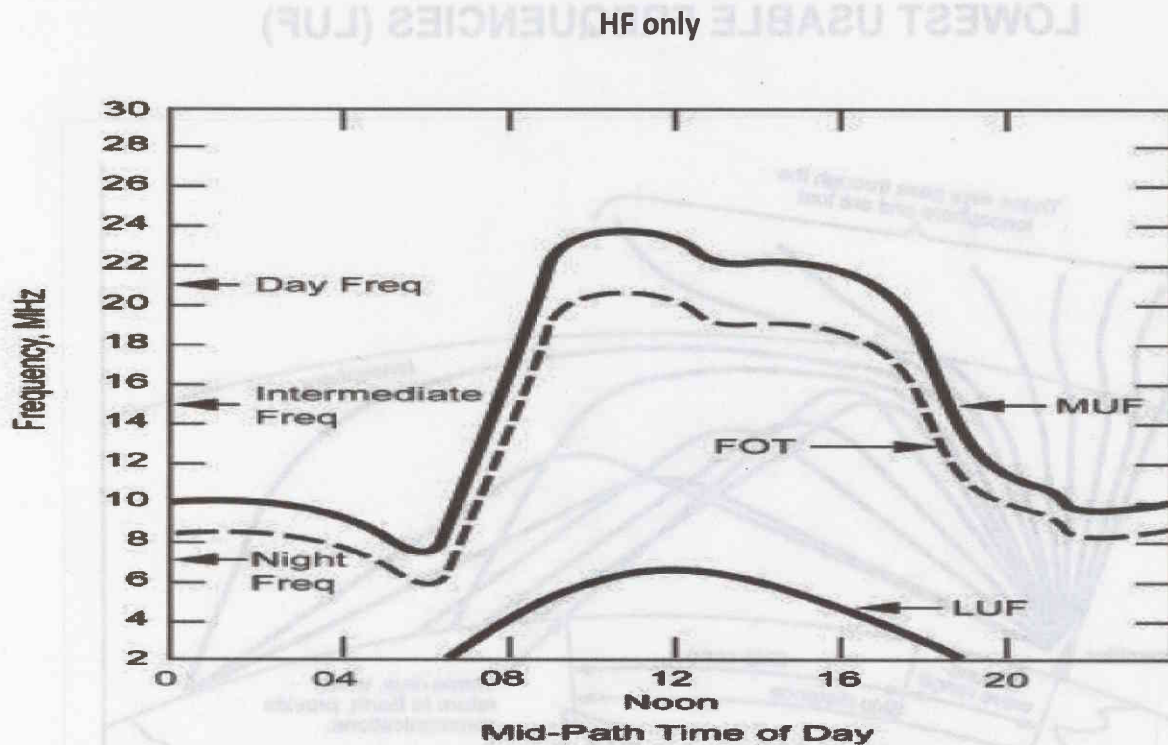


Yes, there is a difference between Night and Day!



## Radio Wave Behavior

The diagram below depicts a chart used to determine specific frequencies and their usefulness depending on the time of day.



When there is a choice of frequencies to use, it is always best to use a higher frequency. This is especially true when communicating over distances greater than 650 miles. This reduces absorption from any lower layer and minimizes multi-path fading. However, it is generally undesirable to operate at or near the MUF since this frequency is reflected only 50 percent of the time. To allow for day-to-day changes in the MUF and the critical frequency, it is customary to use a frequency that is about 85 percent of the MUF. This lower frequency is known as the frequency of optimum transmission (FOT). It is based on the statistical fact that the FOT lies below the daily variations of the actual MUF about 90 percent of the time. It is not always the frequency for minimum path loss or for minimum fading, and there are times when a frequency 10 percent lower or higher than the FOT will be more reliable. Based on statistics, the FOT represents the best choice for a given path length, time of day, season, and sunspot number.

As hams, we often faithfully follow the advice: get your antenna up as high as you can get it! We do this, and other things (like choosing antennas that have a low angle of radiation) in order to maximize the distance over which we can communicate. An antenna with a particularly high angle of radiation is often disparagingly referred to as a "cloudwarmer", the implication being that if the signal isn't radiated at a low enough angle, it's being wasted. For NVIS, we ignore all this traditional advice, and select instead techniques which will maximize not our DX, but our ability to reliably communicate with other stations within a radius of 0-300 miles.

	HF		VHF			UHF			900 MHz .33 m exRS
	160-10 m Ham	11 m CB	6 m (50 MHz) Ham	2 m Ham	1.92 m Marine	70 cm HAM	.65 m FRS	.65 m GMRS	
License Required	YES	NO	YES	YES	YES	YES	NO	YES*	NO
Max Power	<1500 WTS	4 WTS	<1500* WTS	<1500* WTS	5-25 WTS	<1500* WTS	0.5 WTS	< 5 WTS	2 WTS
Working Distance	Up to global	LOS not to exceed 150 miles	LOS+R*+I*	LOS+R+I	LOS to 60 nautical miles	LOS+R+I	LOS	LOS	LOS
Not Channelized	Y	N	Y*	Y*	N	Y*	N	N	Y
Mode(s)									Spread Spectrum
AM	Y	Y	Y	Y	N	Y	N	N	N
CW	Y	N	Y	Y	N	Y	N	N	N
digital modes (PSK, Olivia, etc.)	Y	N	Y	Y	N	Y	N	N	N
SSB Digital Voice	Y	N	Y	Y	N	Y	N	N	Y
Digital Voice	N	N	Y	Y	N	Y	N	N	N
Fixed digital message (ALE)	Y	N	Y	Y	N	Y	N	N	N
FMI	Y	N	Y	Y	Y	Y	Y	Y	N
forwarding systems only (APRS/eMail)	Y	N	Y*	Y	N	Y	N	N	N
Packet	Y	N	Y	Y	N	Y	N	N	N
RTTY	Y	N	Y	Y	N	Y	N	N	N
SSB phone*	Y	Y	Y	Y	N	Y	N	N	N
Encryption	N	N	N	N	N	N	N	N	Y
Repeater	N*	N	Y	Y	N	Y	N	N*	N
Mature Technology	Y	Y	Y	Y	Y	Y	Y	Y	N
Intel	Y	?	Y	Y	N	Y	?	N	N
Entry Level Cost	\$ 350	\$ 50	\$ 100	\$ 100	\$ 100	\$ 100	\$ 15	\$ 25	\$ 40
NVIS	Y	N*	N	N	N	N	N	N	N
Total Y Score	13	3	13	14	2	14	2	2	3

LOS = Line of Sight ~ 5-7 miles

R = Repeater 50+ miles

I = Internet

Intel = Intelligence

SSB Phone = Most efficient use of power

eXRS uses 50 of 700 channels at a time