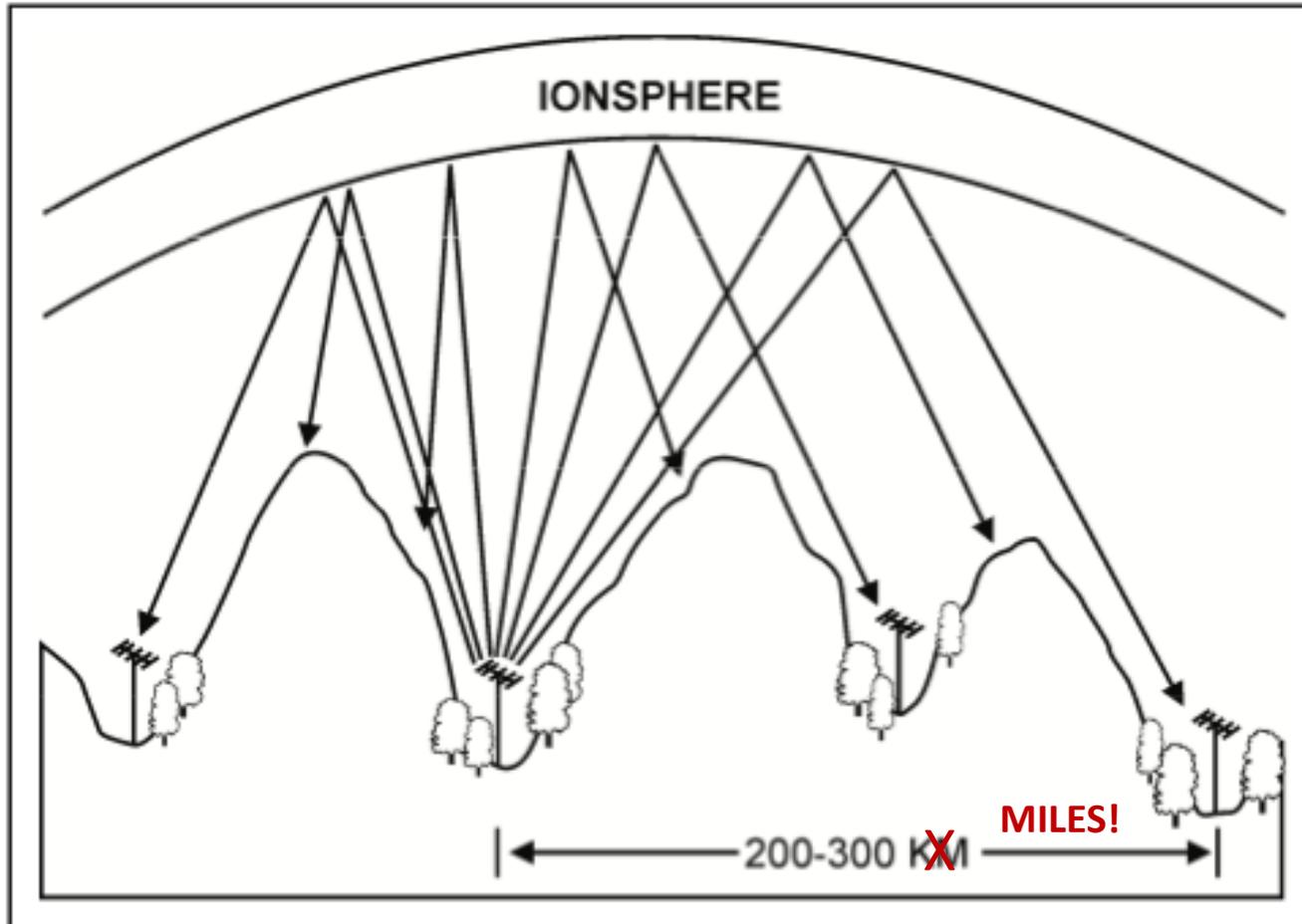


Near Vertical Incidence Skywave (NVIS)

A Tool for Amateur Regional Emergency Communications

Dave Moore N7RF – Sept. 2018



NVIS propagation

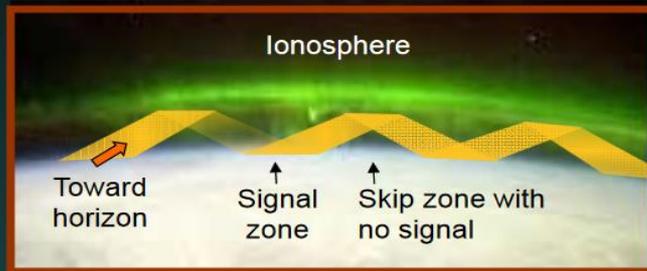
Making Use of the Ionosphere- DX vs NVIS

The very same ionospheric layer is used to reflect signals when operating DX or NVIS. The difference is the angle at which you launch your signal..

DX operating always emphasizes getting your antenna beam as low to the horizon as possible. This allows your signal to skip as far as possible.

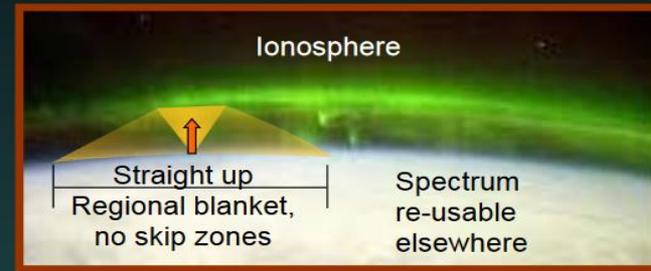
NVIS operating is precisely the opposite. NVIS stations aim for putting most of the signal straight up overhead (70° - 90°). The signal reflects just as well but covers the local area geographically centered on your station.

The more common “long-haul” HF



- Signal toward the horizon
- High power, often 1KW+
- Antennas must be elevated
- May or may not work
- Has dead “skip” zones
- Spills beyond intended area
- Makes spectrum re-use difficult

HF-NVIS



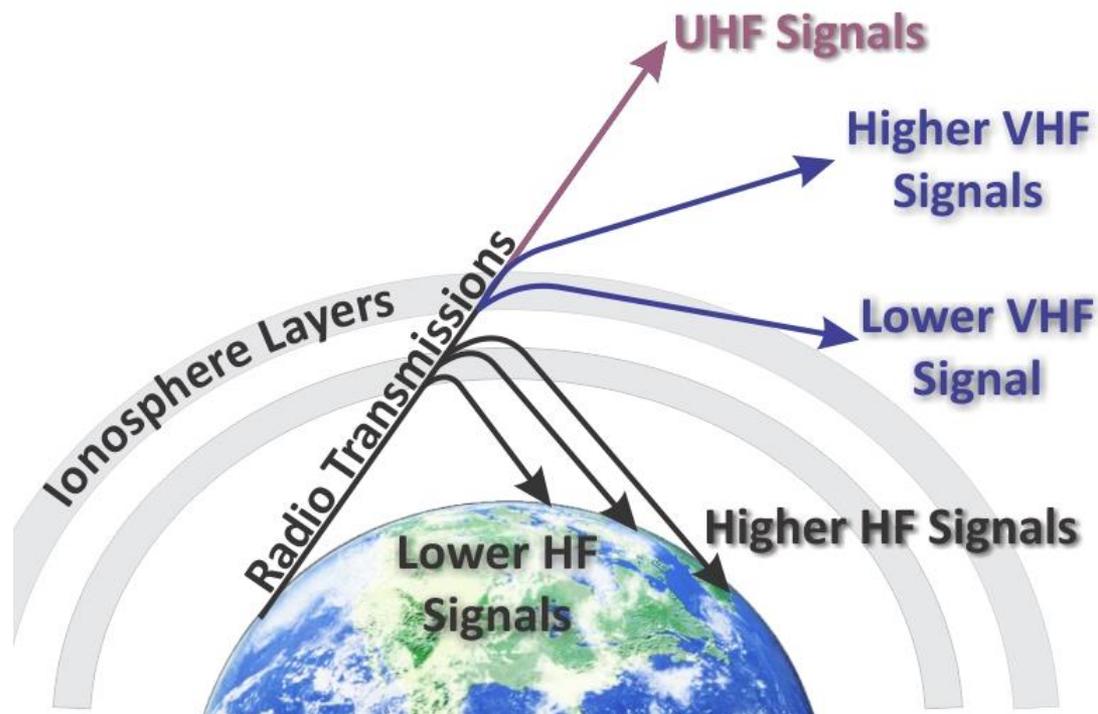
- Signal straight up
- Low power, 125W is plenty
- Antennas stay near the ground
- Virtually always works
- Blankets entire region
- Stays in the regional area
- Re-assign spectrum elsewhere

How the Ionosphere Works - DX vs NVIS

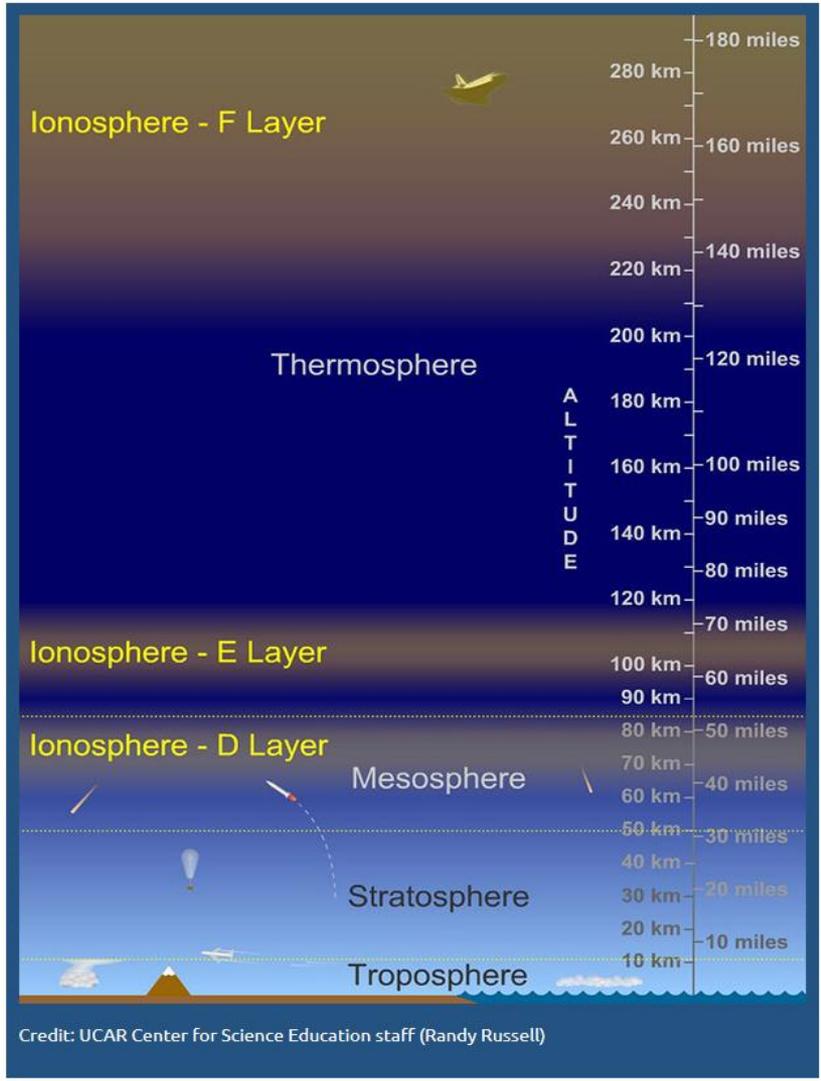
Principle: the higher you go in frequency, the lower the elevation angle whereby the ionosphere will support reflection.

(1) This is why NVIS works best at the low end of the HF range (1-12 MHz). Higher frequencies do not reflect straight overhead.

(2) This is why signals skip farther as you go up in frequency.



Layers of the Ionosphere – 60 km to 1,000 km



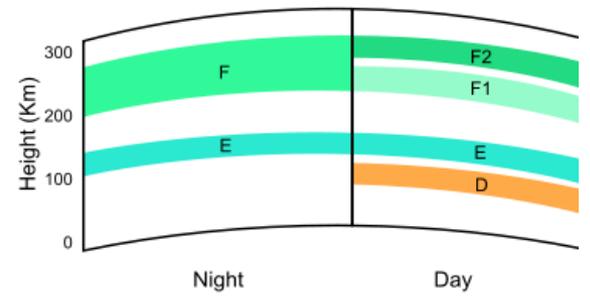
↑ **Topside** – Above F layer (H⁺, He⁺) (Insignificant radio reflection) ↑

F Layer 150 – 500 km

F2 Layer – day and night (O⁺)
 Primary skip region for HF
 F1 Layer – day time only (NO⁺)
 Skip at lower HF frequencies

E Layer 90 - 150 km (O⁺) – weaker at night

D Layer 60 – 90 km (NO⁺) – day time only



Measuring the Ionosphere – the Science of Predicting Propagation – the Vertical Incidence Sounder (VIS)

How does it work? The VIS consists of a variable frequency transmitter, a tracking receiver that follows the transmit frequency, and a NVIS antenna capable of launch the signal straight up. The VIS acts as a radar by receiving the signal reflected back off the ionosphere. The altitude of reflection is calculated directly by the propagation time up and back again. From the properties of the reflected signal, the density of the ionization layers can be estimated. Knowing this, radio propagation can be predicted at angles other than straight up.

Data Online. There is a network of world wide sounders of the type designed by the University of Massachusetts Lowell’s Center for Atmospheric Research (UMLCAR) and referred to as Digisondes™. Anyone can access the current and past data collected by each station here:

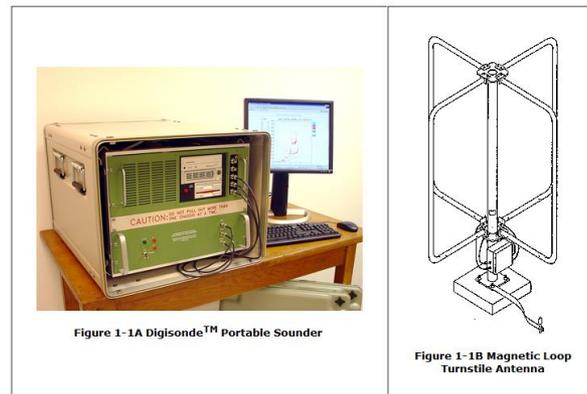
<https://lgdc.uml.edu/common/DIDBFastStationList>

Austin, Texas, is the network station closest to us.



Quasi-modern 300W UMLCAR Digisonde™ →

← National Bureau of Standards original multi-frequency ionosonde, 1939



What Does a Good Ionogram Look Like? – Peak of the Cycle

Here is a typical **day time** ionogram from Austin taken near the peak of the 24th solar cycle on November 15, 2013, 3:00 PM Local

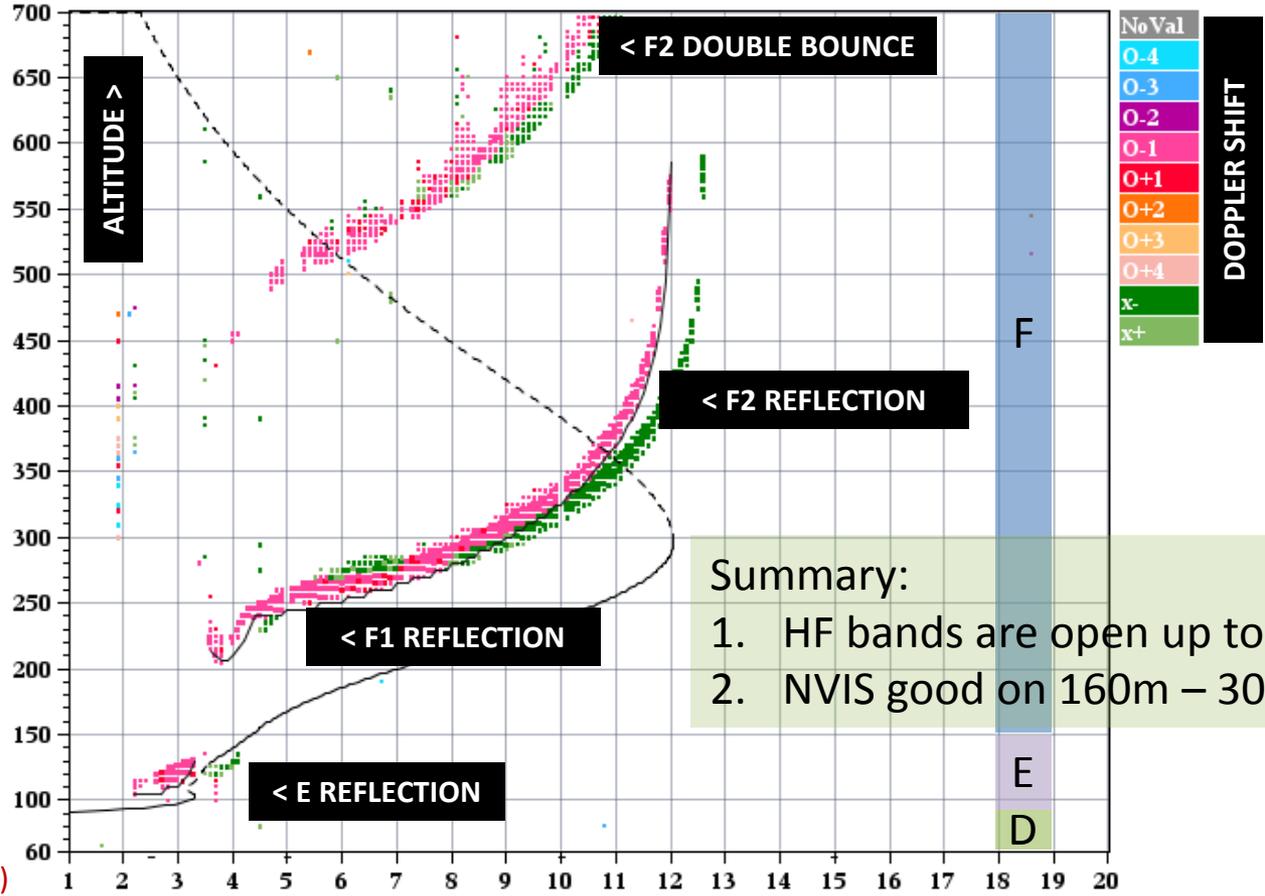
NVIS upper limit frequency

Back to statistics for [2013.11.15 \(319\)](#)



foF2	12.050
foF1	4.75
foF1p	4.59
foE	3.32
foEp	3.24
fxI	12.70
foEs	3.30
fmin	2.20
<hr/>	
MUF(D)	35.58
M(D)	2.97
D	3000.0
<hr/>	
h`F	206.0
h`F2	240.0
h`E	105.0
h`Es	105.0
<hr/>	
hmF2	295.8
hmF1	162.0
hmE	102.9
yF2	104.4
yF1	31.8
yE	12.5
B0	110.9
B1	2.08
<hr/>	
C-level	11
<hr/>	
Auto:	
Artist4.5	
200311	

Statio YYYY DAY DDD HMMSS P1 FFS S AXN PPS IGA PS
 AUSTIN 2013 Nov15 319 200005 MMM 1 045 100 34+ 11



- Summary:
1. HF bands are open up to 10m
 2. NVIS good on 160m – 30m

NVIS Regime (out to 300 miles)

D	100	200	400	600	800	1000	1500	3000	[km]	DX single hop
MUF	12.7	12.8	13.3	14.2	15.4	17.2	22.4	35.6	[MHz]	

Living at the Bottom of Solar Cycle 24

Here is a typical **day time** ionogram from Austin taken on Sept. 03 (5:00 PM Local)

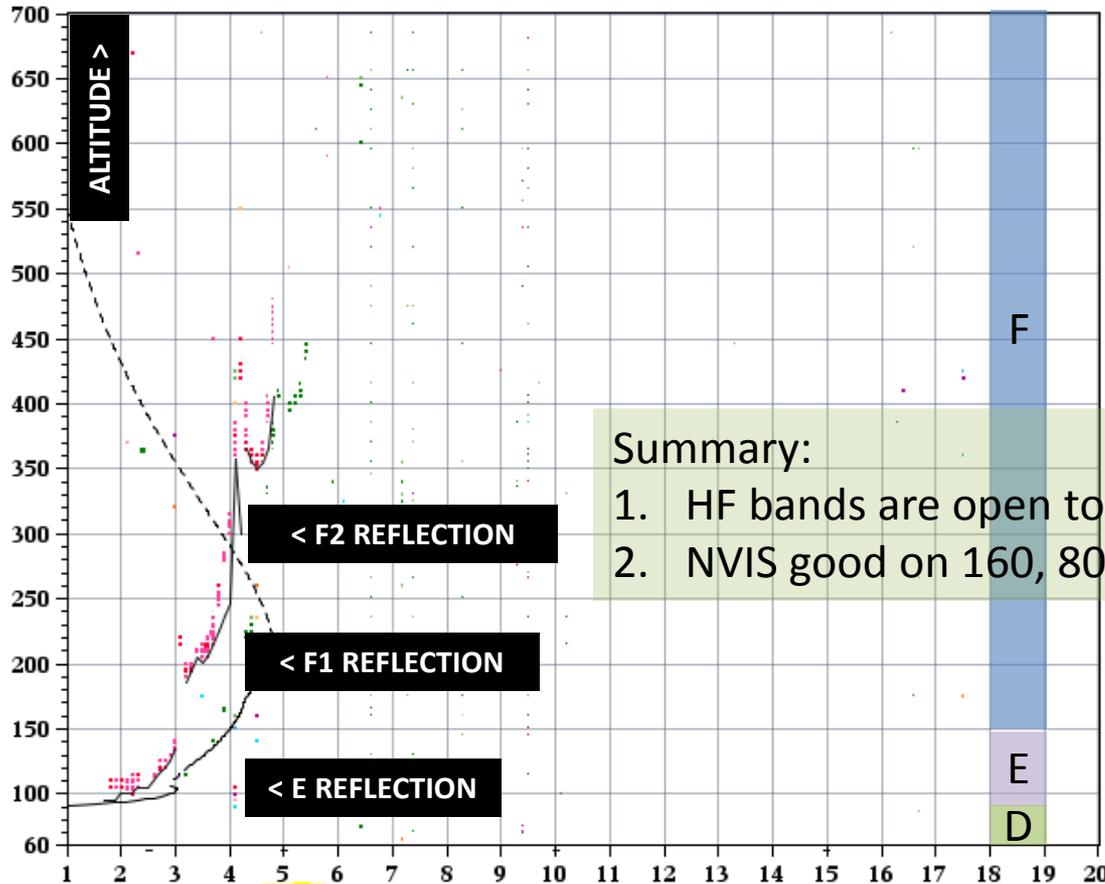
NVIS upper limit frequency

Back to statistics for [2018.09.03 \(246\)](#)



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
 AUSTIN 2018 Sep03 246 210005 MMM 1 045 100 32+ 11

foF2	4.813
foF1	4.25
foF1p	4.27
foE	3.02
foEp	3.12
fxI	5.40
foEs	3.00
fmin	1.70
<hr/>	
MUF(D)	15.32
M(D)	3.19
D	3000.0
<hr/>	
h`F	186.0
h`F2	350.0
h`E	95.0
h`Es	95.0
<hr/>	
hmF2	207.2
hmF1	169.8
hmE	103.8
yF2	49.2
yF1	63.9
yE	13.5
B0	126.5
B1	1.23
<hr/>	
C-level	11
<hr/>	
Auto:	
Artist4.5	
200311	



NoVal
0-4
0-3
0-2
0-1
0+1
0+2
0+3
0+4
x-
x+

Summary:

1. HF bands are open to 20m
2. NVIS good on 160, 80m only

NVIS Regime (out to 300 miles)

D	100	200	400	600	800	1000	1500	3000 [km]
MUF	5.4	5.5	5.7	6.1	6.6	7.4	9.6	15.3 [MHz]

FREQUENCY, MHz >

Living at the Bottom of Solar Cycle 24

Here is a typical **night time** ionogram from Austin taken Sept. 04 (3:00 AM Local)

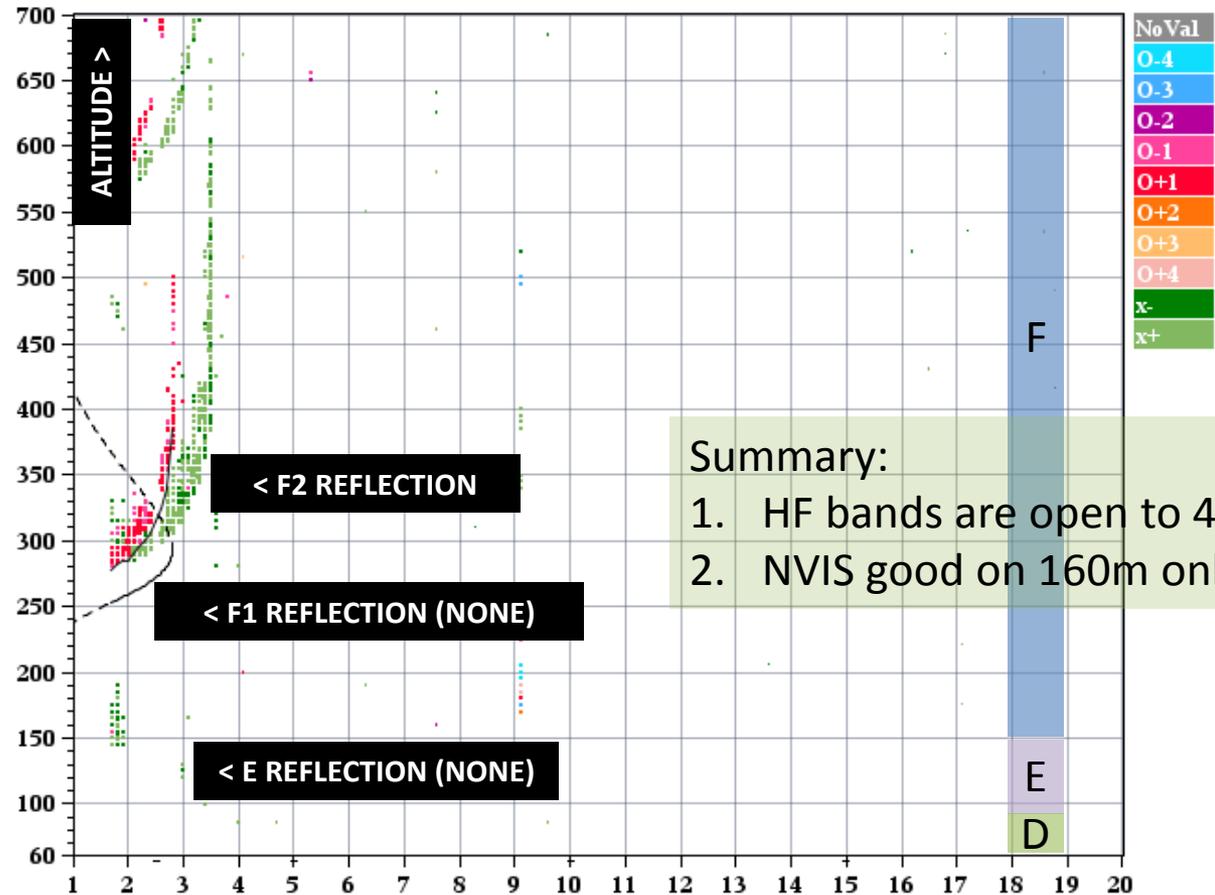
NVIS upper limit frequency

Back to statistics for [2018.09.04 \(247\)](#)



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
 AUSTIN 2018 Sep04 247 080005 MMM 1 045 100 34+ 11

foF2	2.800
foF1	N/A
foF1p	N/A
foE	N/A
foEp	0.38
fxI	3.50
foEs	N/A
fmin	1.70
<hr/>	
MUF(D)	9.17
M(D)	3.27
D	3000.0
<hr/>	
h`F	277.5
h`F2	N/A
h`E	N/A
h`Es	N/A
<hr/>	
hmF2	292.1
hmF1	N/A
hmE	110.0
yF2	47.4
yF1	N/A
yE	20.0
B0	45.8
B1	2.45
<hr/>	
C-level	11
<hr/>	
Auto:	
Artist4.5	
200311	



Summary:

1. HF bands are open to 40m
2. NVIS good on 160m only

NVIS Regime (out to 300 miles)

D	100	200	400	600	800	1000	1500	3000	[km]
MUF	3.4	3.4	3.5	3.8	4.1	4.5	5.8	9.2	[MHz]

FREQUENCY >

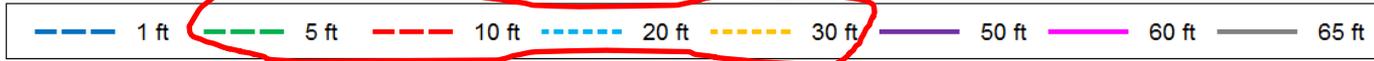
ANTENNAS FOR NVIS COMMUNICATIONS

- **Launch Angle –**
 - A good antenna for DX has a low angle of radiation (aimed at the horizon) to take advantage of F2 layer skip.
 - A good NVIS antenna has a high angle of radiation (aimed up at 70° - 90°).
- **Antenna Types –**
 - Vertical or whip – good DX antenna, terrible NVIS antenna. By nature, verticals project a null straight up.
 - Solution: fold the antenna over so it is mostly horizontal.
 - Dipole or wire (center fed, off-center fed, end fed, multiband, etc.)
 - Radiation pattern results from the currents in the antenna summed with image currents induced in the ground under it. A good dipole (or yagi) for DX low angle radiation is mounted approximately a half wavelength above ground. This results in near cancellation of the energy going straight up.
 - Solution: Mount an NVIS dipole closer to the ground than a half wavelength.
 - Electrically small loop antenna
 - Compact, easy to carry around, launches signal straight up when close to the ground.
 - Disadvantage: less antenna efficiency (lower gain).

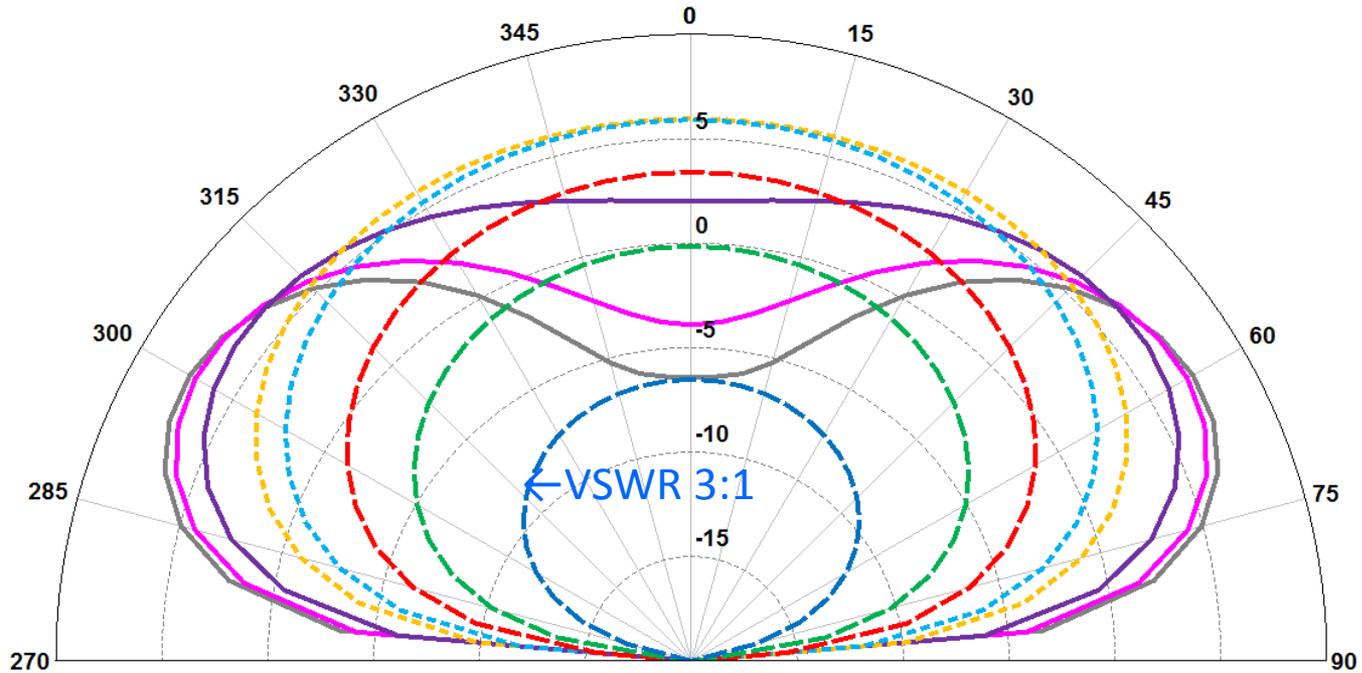
HOW HIGH OFF THE GROUND? 40m Dipole

NVIS →

Dipole Gain vs Height above Ground at 7.2 MHz



Soil Parameters: $K=10$, $S=.005$ S/m

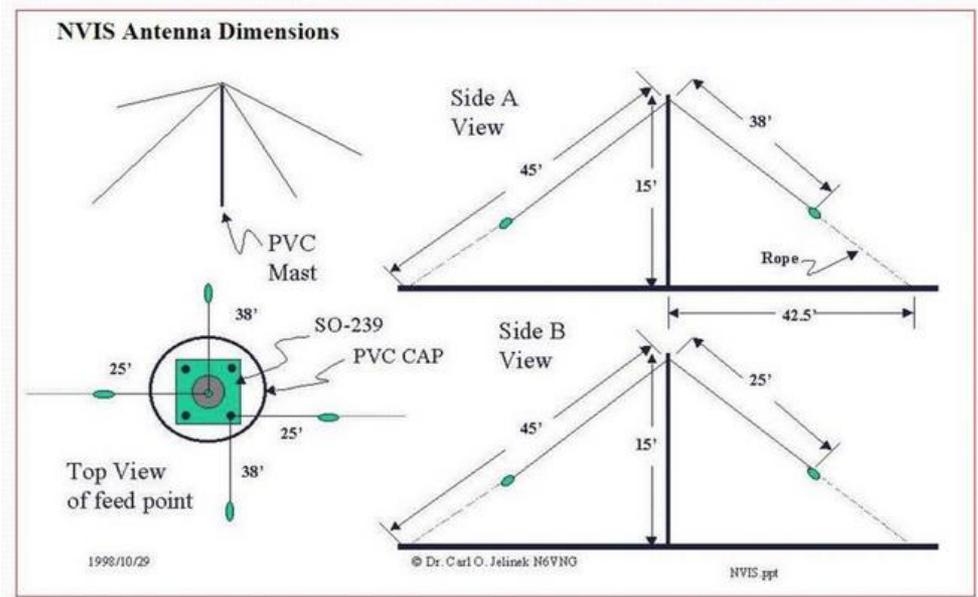


VSWR < 1.5 if 5-ft or more off ground

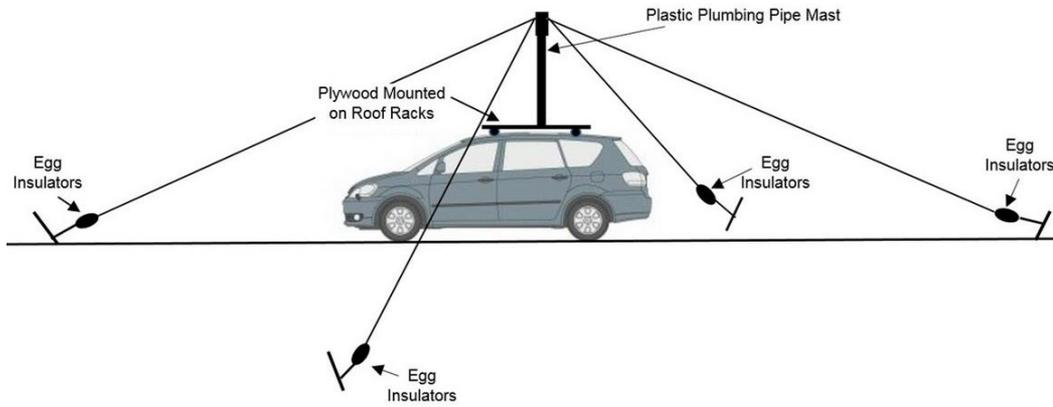
ANTENNAS FOR NVIS COMMUNICATIONS – HORIZONTAL DIPOLES/WIRE



40/80 meter NVIS antenna
(DXEngineering.com)



40/80 meter NVIS antenna (courtesy N6VNG)



ANTENNAS FOR NVIS COMMUNICATIONS – HORIZONTAL DIPOLES/WIRE



Fold over mobile whip antenna



Center-fed pair of electrically short
resonant whips (Hustler, etc.)



Hundreds of NVIS ideas found by Google
search. Improvise almost anything.

ELECTRICALLY SMALL LOOP ANTENNAS

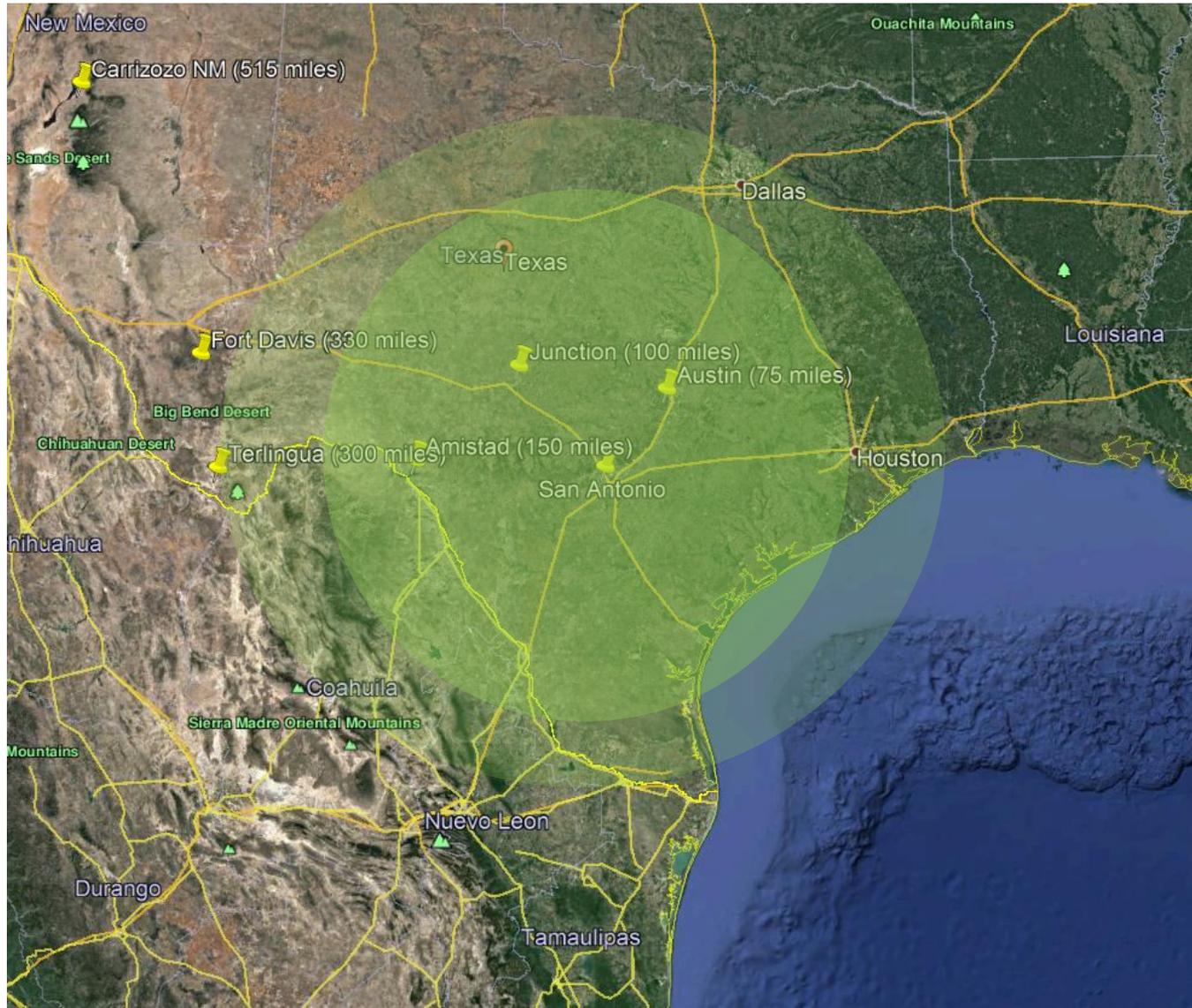


Military style tunable NVIS loop



N7RF 18" tunable loop (30 & 40 meters)

Near Vertical Incidence Skywave (NVIS) – Practical Coverage 200-300 miles



Examples of HF NVIS Use

- **World War II.** By 1944, NVIS was well understood. American radio pioneer Dr. H. H. Beverage assisted the Army Signal Corps in planning D-Day communications. NVIS was used between England and all the forward communications centers on the landing beaches.
- **USMC.** In 1989, the Marines verified the effectiveness of NVIS mobile communications in an exercise extending from South Carolina to Virginia. Mobile and fixed stations reported near-100% reliability.
- **US Navy.** In 1995, CNO and SPAWAR incorporated HF NVIS as a battle force secure electronic mail system to augment SATCOM and VHF SINCGARS radio systems.
- **California State Military Reserve.** In a 1994 exercise, CSMR demonstrated reliable digital PACTOR HF communications by proper selection of NVIS antennas and frequency management plan based on ionospheric conditions.
- **US Army.** Chapter 3 of Army manual 24-18, entitled Tactical Single Channel Radio Communications Techniques, discusses NVIS communications. In Vietnam, radiomen discovered vehicle radios worked better when the whips were tied down horizontally. NVIS was also used to communicate with Special Forces operating on the other side of mountain ranges from command.
- **Who uses NVIS?** Federal, state (national guards), and local governmental agencies, and critical infrastructure operations such as power authorities, gas/oil pipelines, airports, and hospital networks.
- NVIS is also part of planning by USAFA Civil Air Patrol, RACES, MARS, and ARRL ARES organizations.

QUESTIONS?