Mysteries of the 160 meter band

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Agenda

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  - Layer D
  - Layer E
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- 160 meter propagation factors
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Introduction

160 meters band behaviour is unique according to Top Band experts:

No simple methods for predicting propagation as there is with HF-VHF bands

John Devoldere, ON4UN “Antennas and Techniques for Low-Band DXing“

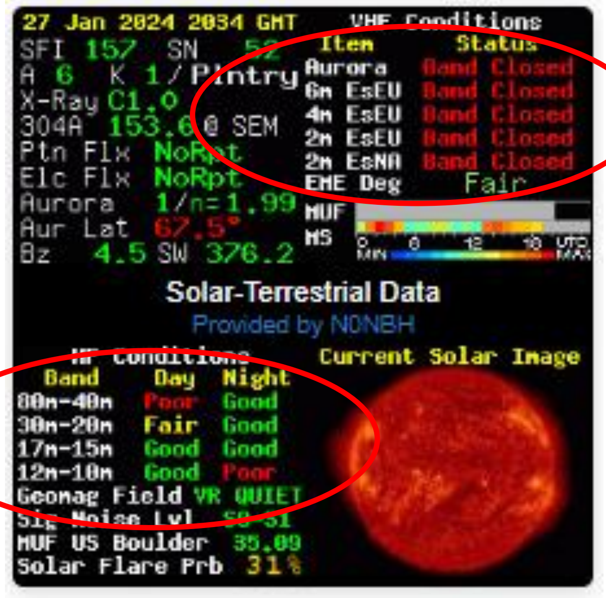
- “The more I have been active on 160, the more I am convinced on how little we know about propagation on that band.” [1]

Jeff Briggs, K1ZM, “DXing on the Edge--The Thrill of 160 Meters“

- “To me, personally, the biggest task yet unmet on the top band is figuring out just what makes 160 meters tick.” [2]

Bill Tippett, W4ZV (first ham operator to work 300+ DXCC on 160 meters)

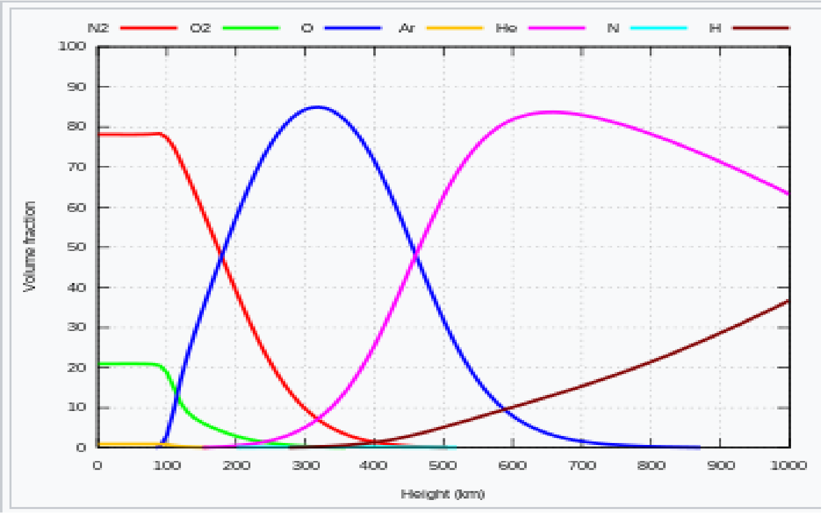
- “If 160 were perfectly predictable, we would all become bored with it and take up another hobby. The thrill of working a new DXCC on 160 meters is ten times the thrill of doing it on 80 meters!”



No predications for 160 meters !

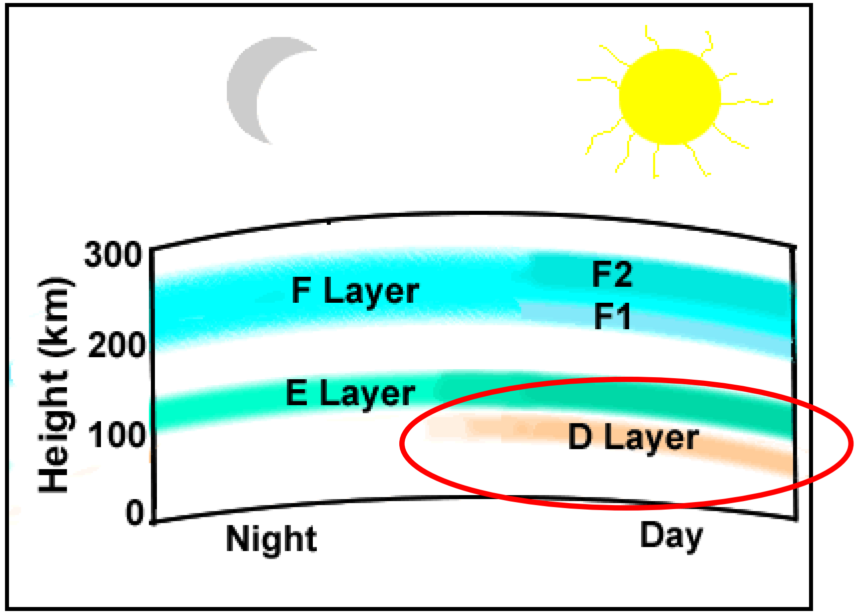
General HF Propagation

Ionosphere consists of:
- N_2+, O_2+, electrons in lower thermosphere (100< km)
- O+, electrons at peak density (~300 km)
- He+, H+, electrons at high altitudes (>400 km)
- Free electrons reflect or absorb radio waves



D Layer (Absorptive layer): 50-90 km height
<u>Daytime:</u> This layer is created by sun's UV radiation
- D layer blocks ionospheric path on 40 to 160 meters during day
- 30 meter and higher bands passthrough D layer during daytime

<u>Night:</u>
- D layer density decreases significantly
- 40 to 160 meter signals are able to reach upper layers
- D layer has a more complicated relationship with 160 meters



General HF Propagation

E Layer (Reflective layer): 90-140 km height

Daytime:

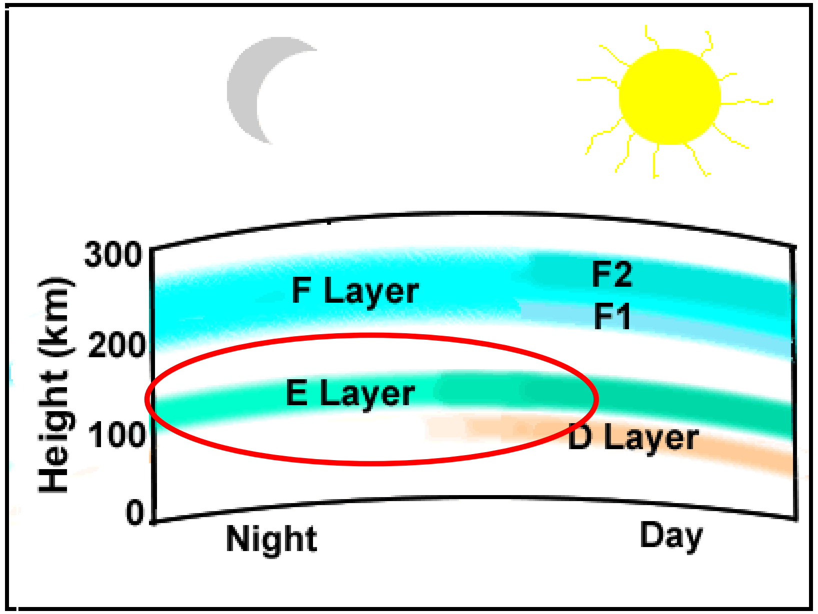
- Signals in 7-14 MHz range, transmitted near vertically (NVIS) punch through D layer to reach E Layer and reflected <1200 km

Just before dawn and right after dusk:

- Best times to make use of the Layer E

Night time:

- Layer E weaker, but still partially useful for 160 meter propagation



Sporatic E

- Sometimes dense ionized clouds form suddenly in Layer E and disappear just as suddenly (within minutes to hours)
- These clouds can provide DX propagation on VHF bands

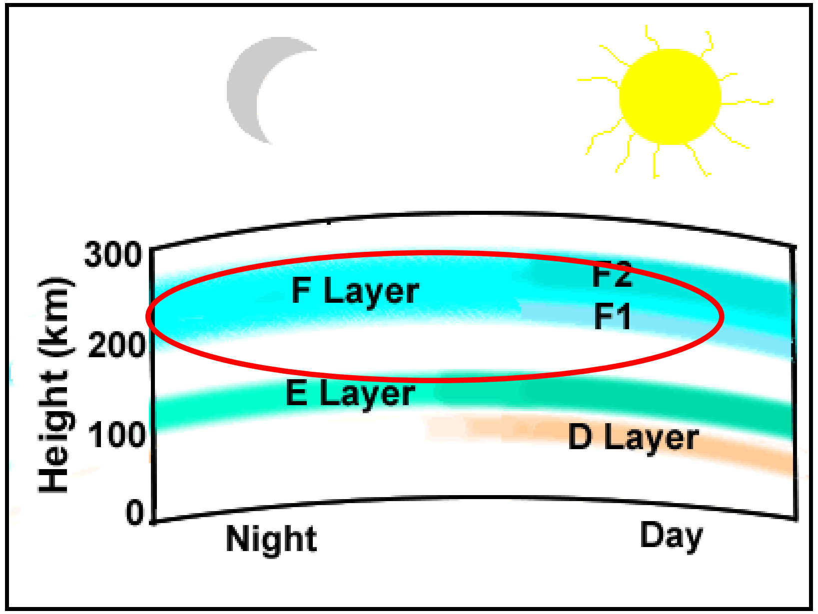
General HF Propagation

During daytime separate layers F1 and F2 are present

Layer F1 (Reflective layer): 200-250 km height
- Minor role in 30 and 20 meter band propagation

Layer F2 (Reflective layer): 250-400 km height
- Major role for most HF ionospheric propagation
- Layer F2 has highest density during solar sunspot cycle peak
- Can disappear completely for days during solar cycle minimum

- Reflects radio signals on 7 to 30 MHz up to 4000 km away
- Signals can rebound via multiple hops between Layer F2 and earth, capable of doing a complete 360 trip around the earth



Layer F at night is the merger of Layers F1 and F2 (300 km)
- Primarily responsible for night time propagation on HF bands and 160 meter band

Electron Gyrofrequency

1) Gyrofrequency is measure of interaction between:

➔ Layer D charged particles and earth's magnetic field [1]

➔ Gyrofrequencies range from 600 - 1800 kHz

➔ Energy is absorbed most near or at contour frequency

2) Most impacted ➔ perpendicular to Earth's magnetic field

➔ N-S paths are less affected than E-W paths

➔ NA to Europe and NA to Japan ➔ most impacted

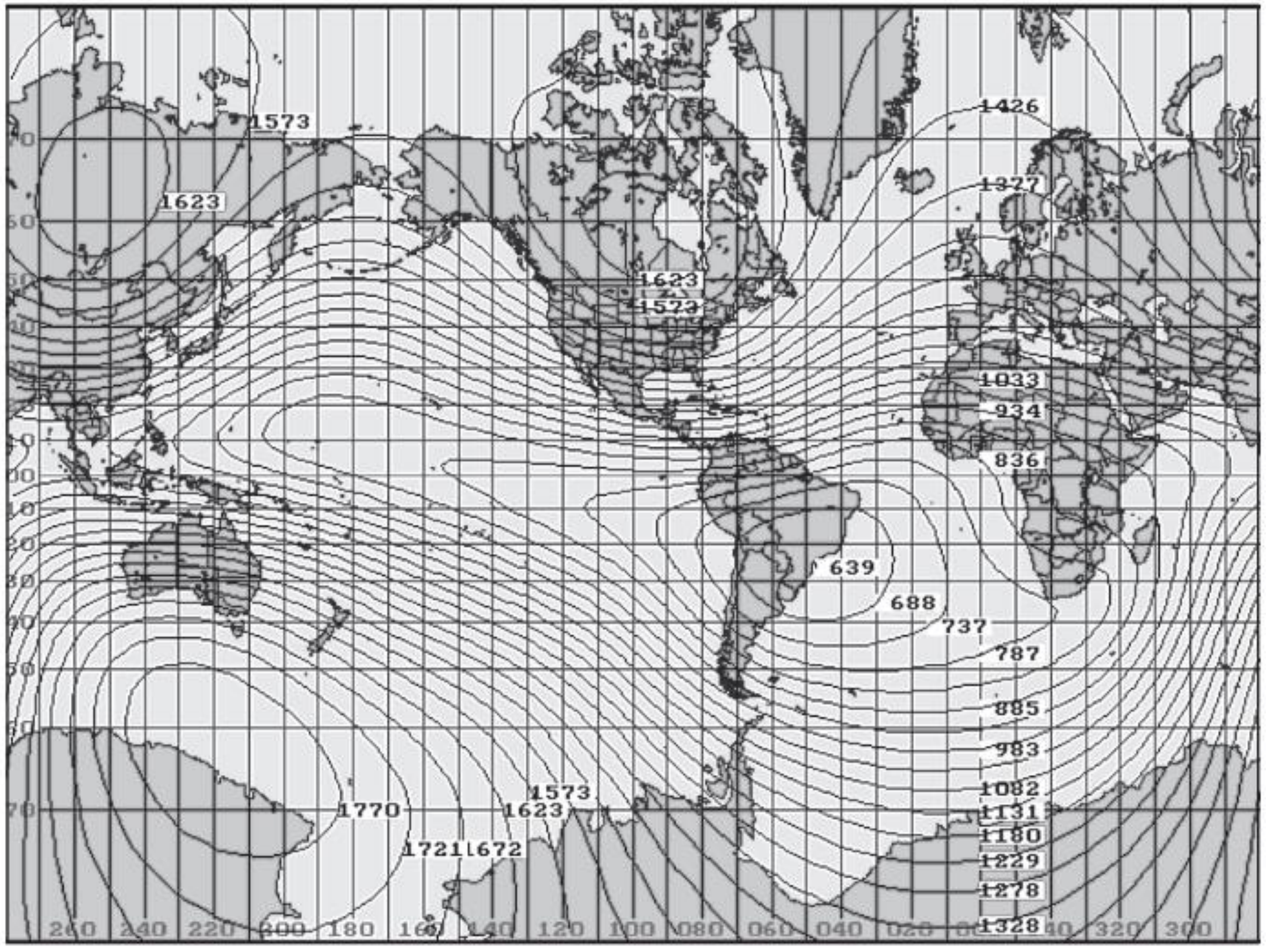
3) Geomagnetic activity during solar activity

➔ Orientation of Earth's magnetic field lines can change

➔ Changing Rx signal strength.

➔ Often signals are degraded below useable levels

➔ <u>Other times significant signal enhancement can occur</u>



Auroral Ovals

Auroral ovals originate from:

- Electrons leaking out along magnetic field lines from plasma sheet of Earth's magnetic tail [3]
- Form at or near North and South poles

Signal path or inside auroral ovals can experience different behaviors:

1) Strong signal absorption (which is usually what happens)

2) <u>Brief periods of strong signal enhancement</u> primarily caused by tilts in ionosphere that focus signals to your location

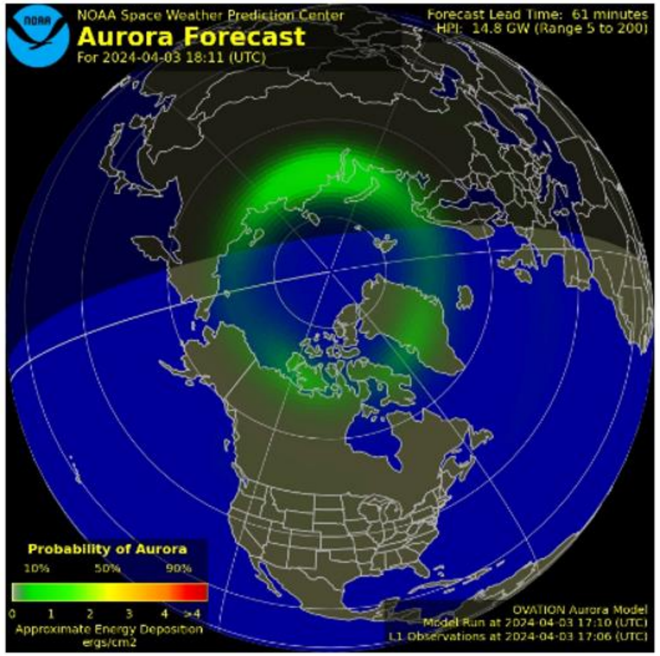
3) Erratic signal behavior: strong-rapid fading caused by multipathing and rapid variations polarization changes

4) During exceptionally quiet geomagnetic conditions

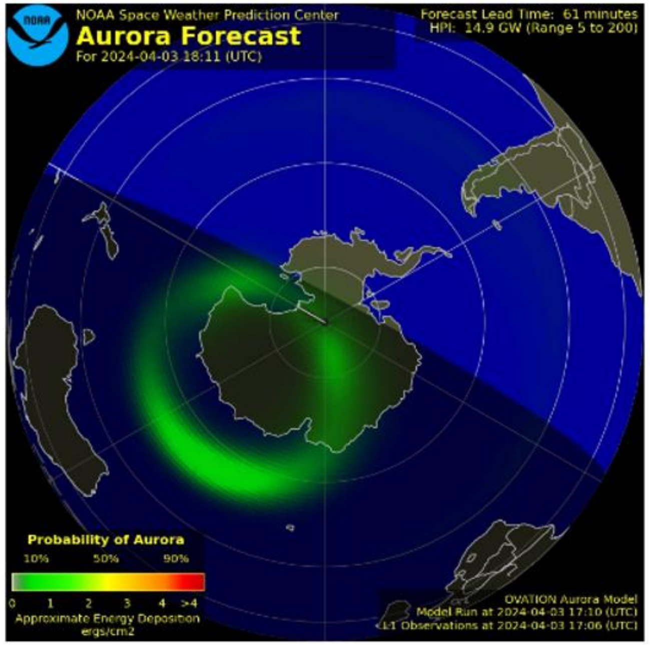
➔Auroral zone contracts and passes signals unscathed through polar caps

➔Small increases in geomagnetic activity can produce large changes in the position of auroral zone

Northern hemisphere



Southern hemisphere



Grayline

Gray line is the terminator separating night and day (sunrise/sunset) [4]

- 160/80m enter/exit at right angles while other bands travel parallel to terminator
- Greatest distances can be covered across darkness, if opposite ends of the path are located near the terminator.

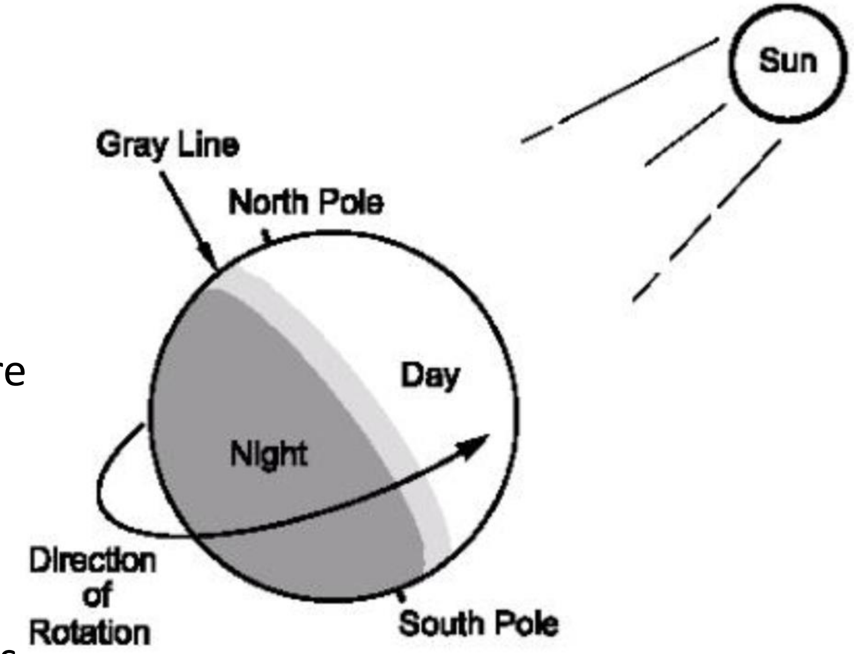
There are two special effects which take place at sunrise and sunset.

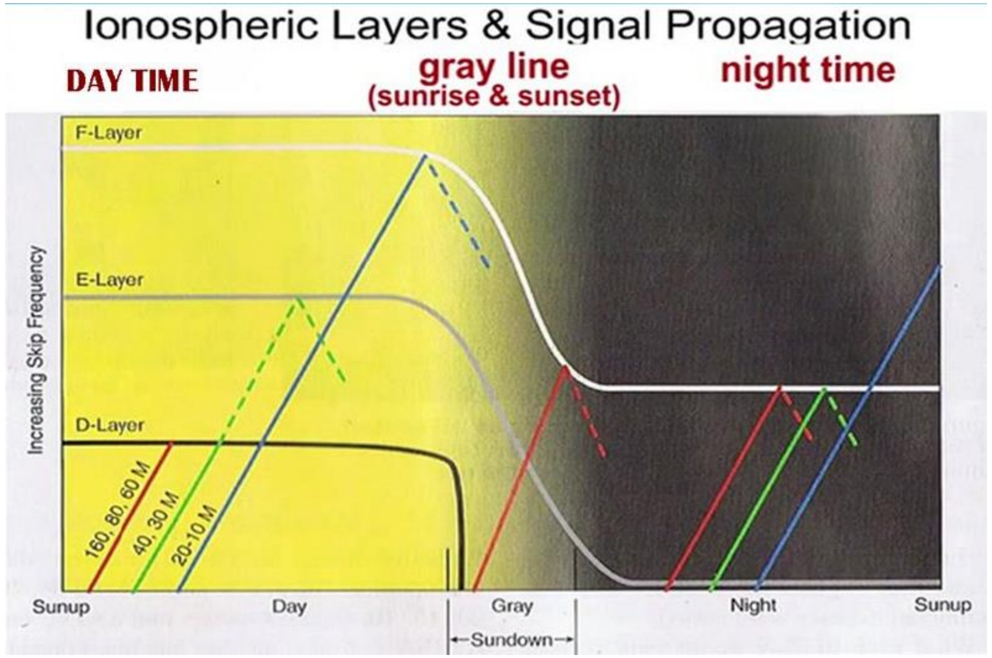
1) Sunrise enhancement **SRE** peaks signals from west

- Focusing effect ➔ refractions of F and E layer combine to produce significant gains (6 to 10 dB or more). This effect lasts:
  - Few minutes on 160 meters at sunrise +/- few minutes
  - 10 to 20 minutes on 80 meters after sunrise
  - 30 to 60 minutes on 40 meters after sunrise

2) Sunset enhancement **SSE** peaks signals from the east similar to **SRE**.

- 80 and 40 meters signals always peak before sunset
- 160 meter signals can peak at sunset as well as during darkness.

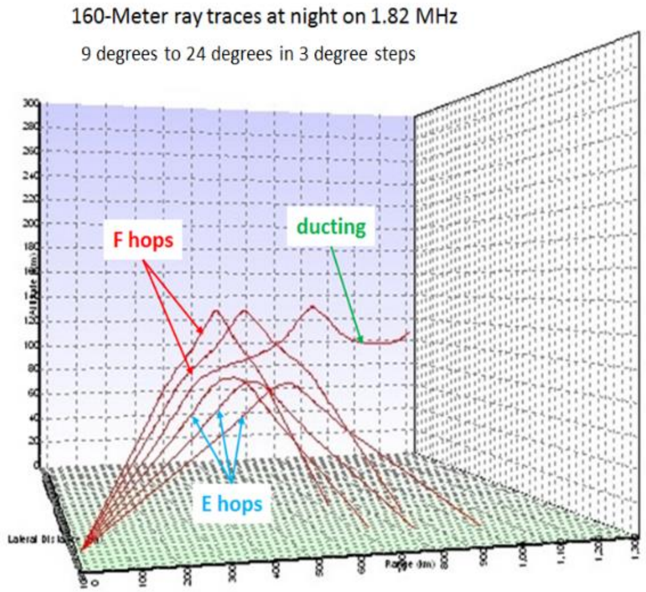




Ducting

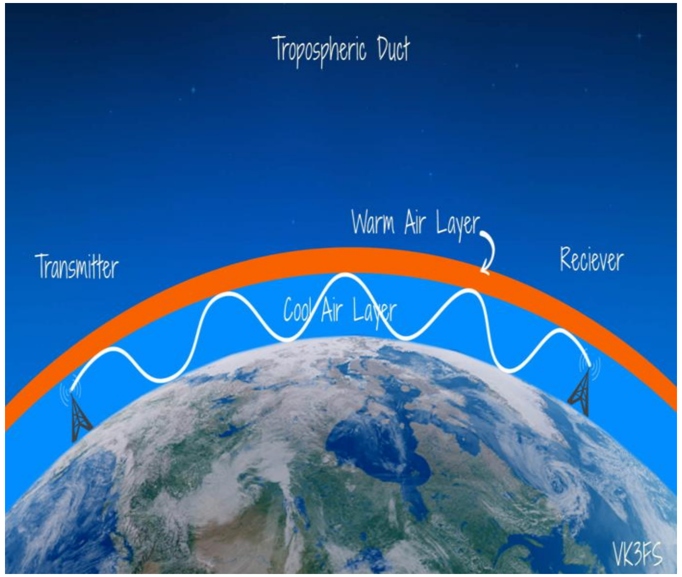
Many 160 meter DX contacts greater than 4,000 kilometers are due to signal ducting. [3]

- A radio signal enters into an ionospheric “tunnel” will duct between walls of tunnel until walls either disappear or become weak enough to permit signal to break through.
- E- and lower F-regions electron densities are sufficient for 160m signals to be ducted if they can enter these regions at just the right angles under the right conditions.
- <u>Ducts can exhibit non-reciprocity; you may hear someone but they cannot hear you</u>.
- This phenomena is much more common on 160 meters than on higher frequencies.



<u>Difference between ducting on 160 meter and 6 meters:</u>

- **160 meter ducting**: Signals reflect between two ionized layers: E and F
- **Tropospheric duct**: VHF signals refract (bend) at junction of cold and warm air fronts
  - It happens a low altitude typically 10 km.
  - Ducting contained within cool air layer or warm air layer



Chordal Hops

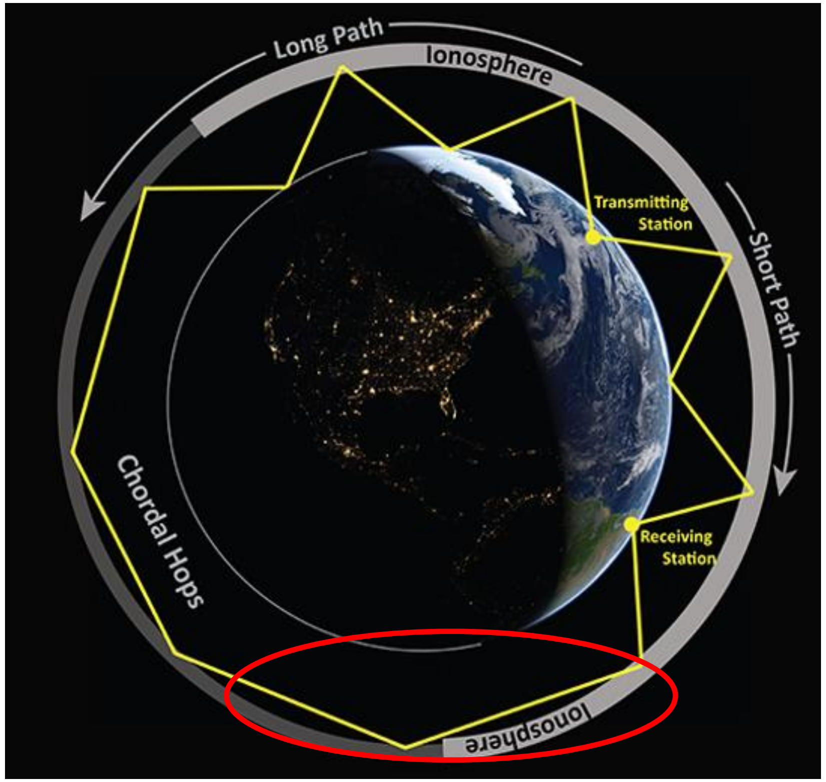
Refraction mechanism observed in 160 meter Dx propagation ➔ Choral Hop [1][5]

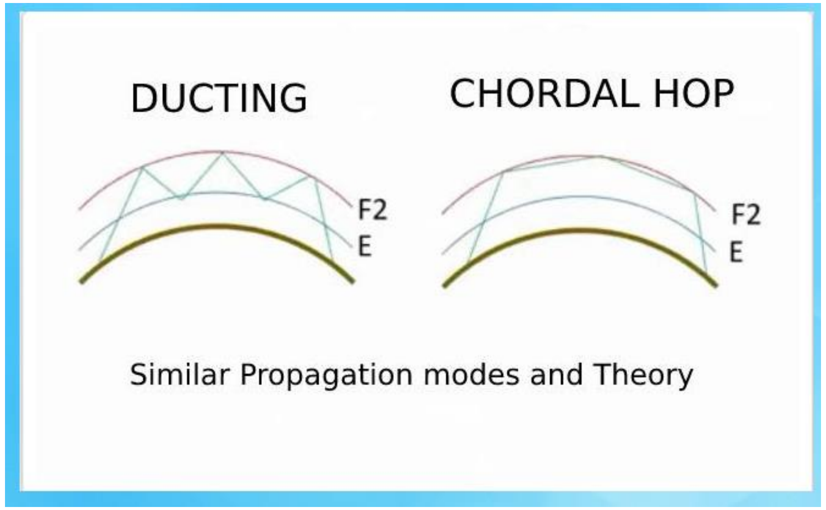
- Chordal hop occurs ➔ signal is refracted by the ionosphere and refracted several times more before hitting the ground.
- Chordal hop propagation ➔ more effective than multi-hop propagation
  Using Earth as a reflector ➔ lossy and limited to a handful of reflections
  Chordal refractions ➔ less lossy than Earth reflections

<u>Chordal-hop over long distances ➔ 12 dB gain due to no ground-reflection losses</u>

<u>**Difference between Ducting and Chordal hop:**</u>

- **Ducting**: 160 meter signal bounces between two ionosphere layers E and F
- **Chordal hop**: Refraction bends 160 meter signal along same ionospheric layer





Predicting optimal 160 meter Operation

- Time of Day
  - Sunset, night and sunrise
  - Experienced 160 meter Dxers consult sunrise and sunset time tables
- Seasonal Cycles
  - December to March
- 11 year Sunspot Cycle
  - Minimal effect on 160 meters
- 28 day Sun Rotation Cycle
  - Experienced 160 meter Dxers watch and record propagation during solar rotations

11-Year Sunspot Cycle

- 80 to 10 meters propagation ➔correlates with sunspot activity (11 year cycle)
- 160 meter propagation ➔ correlates very little with sunspot activity (only 5%)

160 meter signal strength prediction methods disregard sunspot numbers or solar flux levels:

- 160m signal strengths are very difficult to correlate with solar activity
- Signals are reflected in lower regions of night-time ionosphere
- Night time solar ionization is at minimal levels

28 Day Sun-Rotation Cycle

- The sun rotates around its own axis in approximately 28 Earth days. [1]
- Sunspots and other phenomena on the sun can last several solar rotations.
- DXers (low and higher HF bands) look forward to a repeat of very good conditions 28 days later and their expectations are often met.
- This is probably the only somewhat reliable propagation prediction system for 160 meter
- If you had outstandingly good conditions on 160 meters, always mark your calendar for 28 days later. There is a fair chance you may have the same or similar good conditions again.
- However, if conditions today are very bad (maybe due to a solar flare), there’s no telling whether conditions will be bad in 28 days, since a solar flare does not repeat every 28 days

160 meter Myths and Facts

1) 80/160 meters DX can only be worked during winter. This is not true

- December through March is best time for this band.
- 160 meter contests are scheduled during this period
- DX operations are possible during other periods.

2) Skip zones due to MUF do not occur on 160 meters since the MUF is always higher than 1.8 MHz

3) 160 meter operation best during solar minimum, contrary to behavior on HF bands

- During solar minimum, generally fewer solar flares during low point in sunspot cycle

My Experiences on 160 meters

Conventional Propagation

160 meters DX from Montreal within following rectangle:

- Mississippi river to the Atlantic east coast
- Southern Quebec / Ontario / Labrador down to Florida
- NA to Europe ➔ impacted by gyrofrequency (1.6 Mhz) and auroral ovals

Israel and Ukraine

- Night time (10 PM - 2 AM): Ducting and Layer D density change (drop)
- Leaky path, many stations in West/East Europe receiving my signal
- Asymmetrical behavior, many heard me but I only heard a few

Australia and Hawaii

- Sunrise: Grayline + Chordal hop
- Solid path, very short window of opportunity

Liberia

- Sunset: Grayline + Chordal hop
- Solid path, very short window of opportunity

Conclusion

General Guidelines

- Best times for 160 meter operation times: Sunset, Sunrise and night
- Best months: December to March. Operation possible during other months.
- 160 meter Dxers generally ignore sunspot cycle forecasts
- 160 meter Dxers record solar rotation cycles and consult daily sunset/sunrise charts

Phenomenon that mostly exhibits signal attenuation affected by solar rotation cycle

- Electron gyrofrequency impacts layer D, mostly attenuates 160 meters, but sometimes enhances signals
- Auroral Ovals also impacts layer D, mostly attenuates 160 meters, but sometimes enhances signals

Phenomenon that can enhance signals based on time of day, season and physical location of two stations

- Grayline enhancement (6 to 10 dB gain) on paths perpendicular to the terminator at sunset and sunrise
- Chord hopping (multiple refraction) can provide a 12 dB gain compared to conventional propagation

- Ducting via F and E reflections can provide significant gain compared to conventional propagation
- Ducting can suffer from asymmetrical paths. “You hear me, but I cannot hear you” and vice versa

➔ 160 meters is often exercise in futility, but when it opens up it is really exciting to operate.

Acknowledgements

The following figures were "borrowed" from the sources listed below:

Slide 3: Propagation chart from QRZ.com

Slides 4-6: Figures from Naval Postgraduate School

Slide 7: Gyrofrequency map from John Devoldere, ON4UN

Slide 8: Auroral maps from https://www.spaceweatherlive.com

Slide 9: Grayline figure from VE6TN

Slide 9: Grayline figure from WA2OOO

Slide 10: Ducting figure from Carl Luetzelschwab K9LA

Slide 10: Troposcopic duct figure from VK3FS

Slide 11: Chordal ducting figure form hamradioschool.com

Slide 11: Duct vs chordal figure from WA2OOO

Further Reading

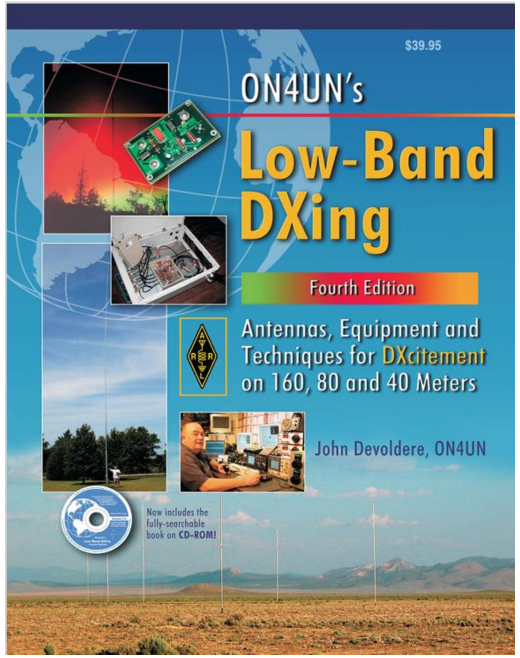
[1] “Low Band Dxing”, John Devoldere, ON4UN

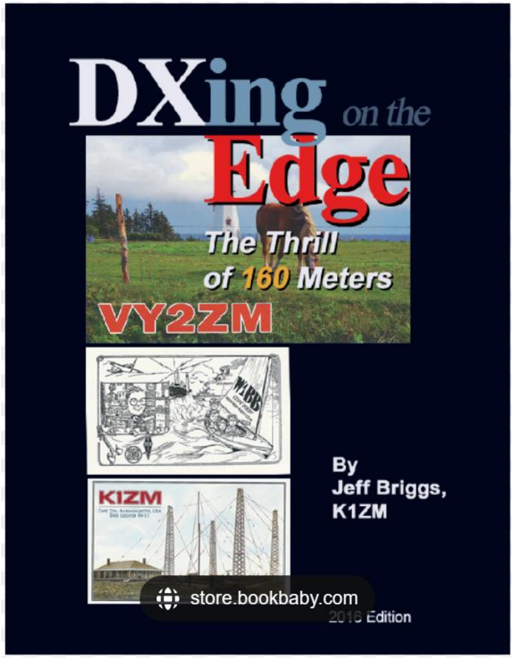
[2] "DXing on the Edge - The Thrill of 160 Meters!", 2nd Edition, K1ZM Jeff Briggs

[3] “The 160-Meter Band: An Enigma Shrouded in a Mystery”, Cary Oler and Ted Cohen (N4XX)

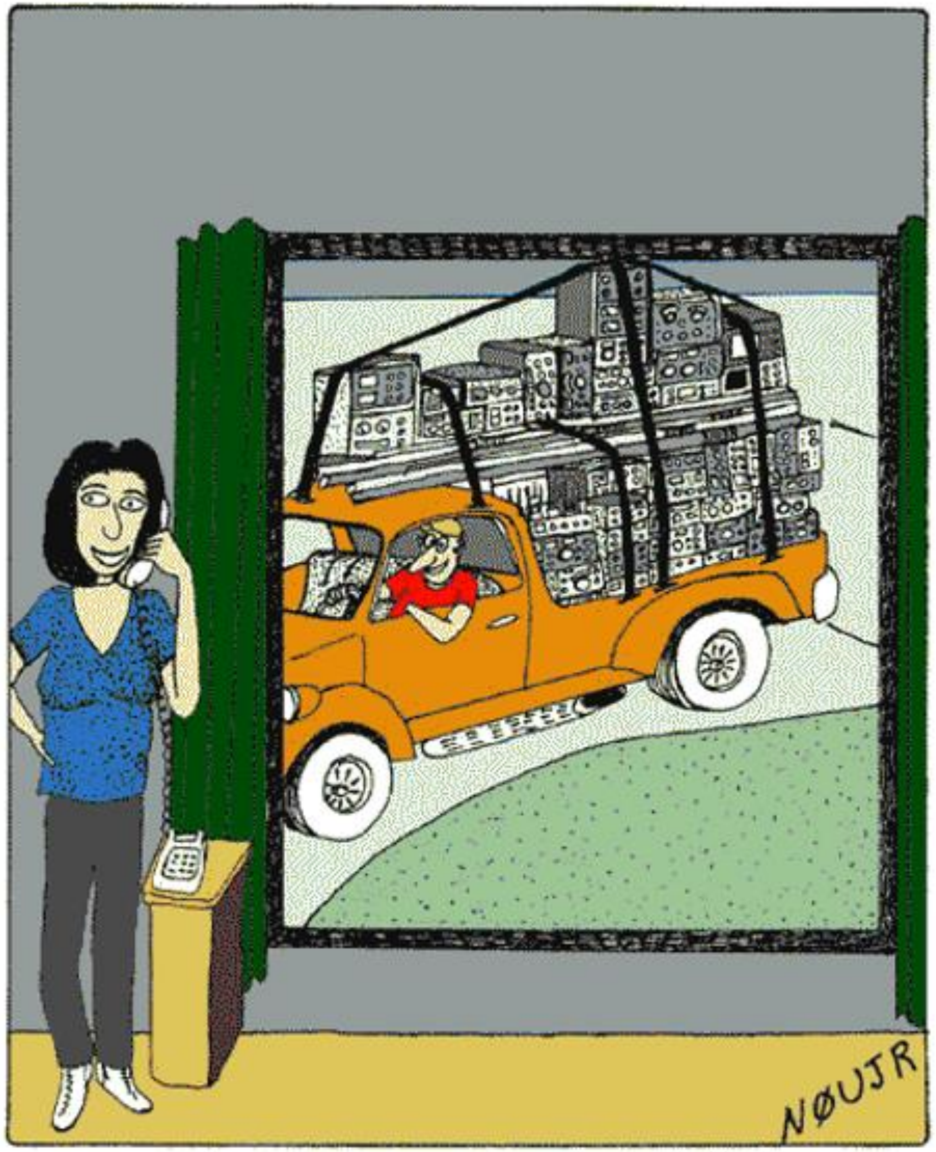
[4] “Ducting and Spotlight Propagation on 160m”, Carl Luetzelschwab K9LA

[5] [Chordal Hop Propagation (hamradioschool.com)]() Stuart Turner, W0STU





Questions ?



"No Greg went to the ham auction this afternoon, to get rid of a couple old radios that were cluttering up the place...Oh I think I hear him pulling in now!"