Chapter 7
HF Propagation

Ionosphere

Solar Effects

Scatter and NVIS

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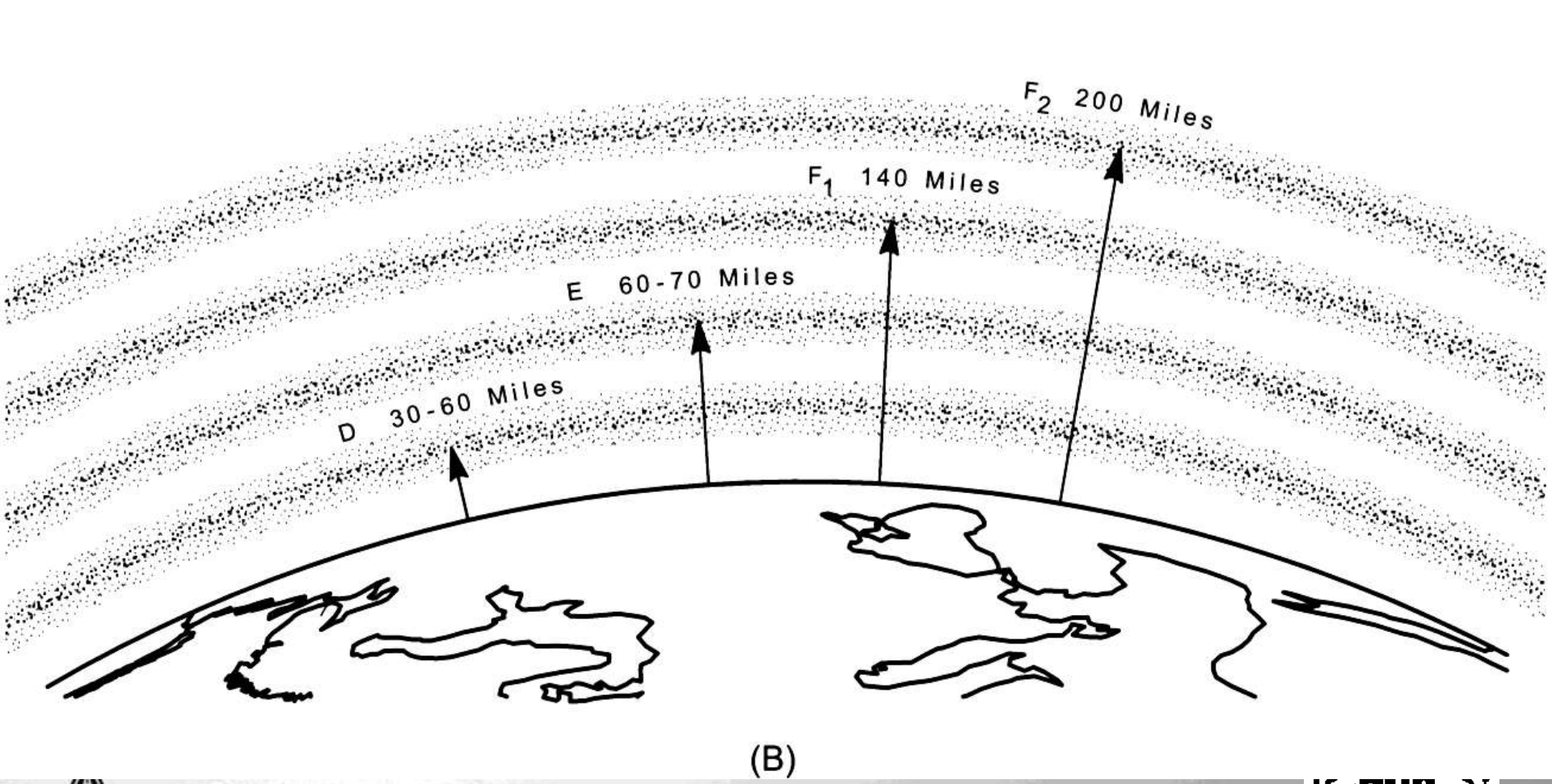
Ionosphere and Layers



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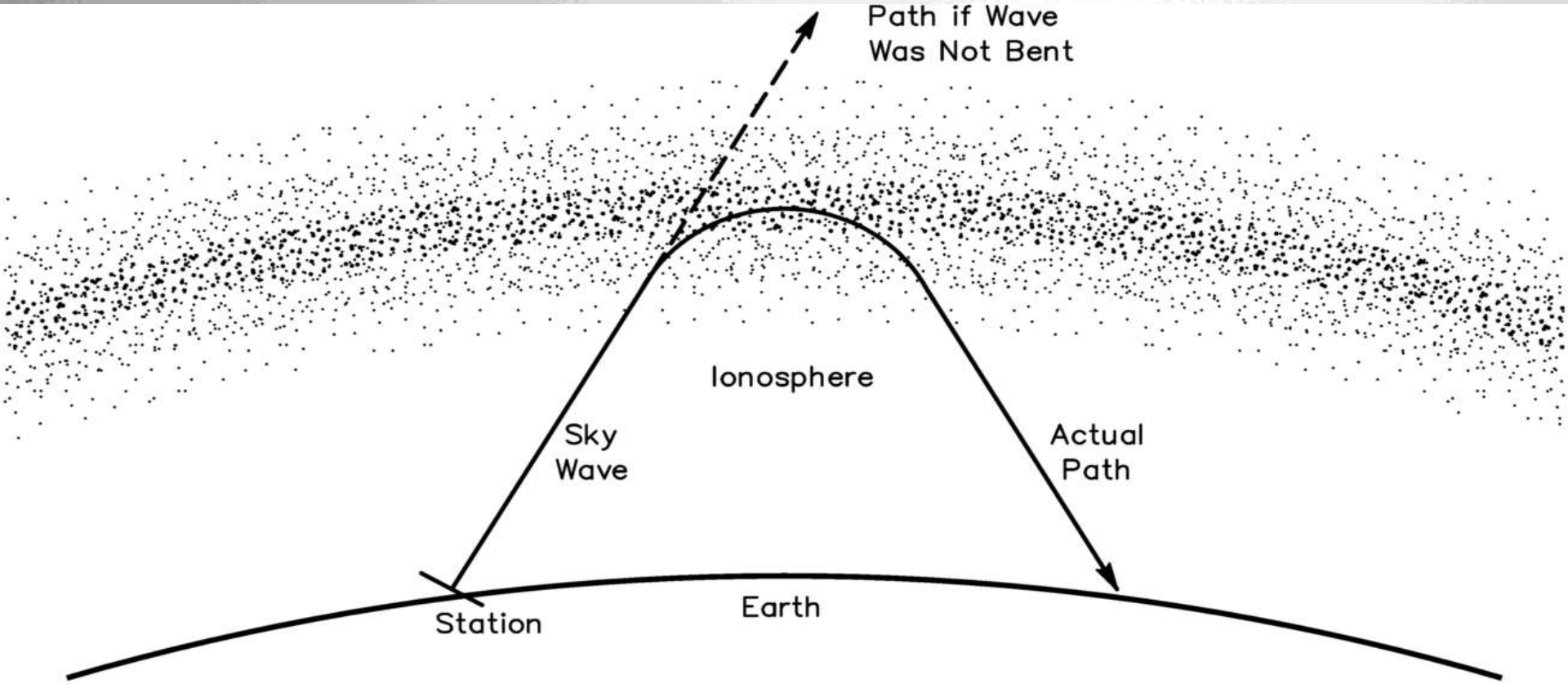
Radio Waves Bent by the Ionosphere



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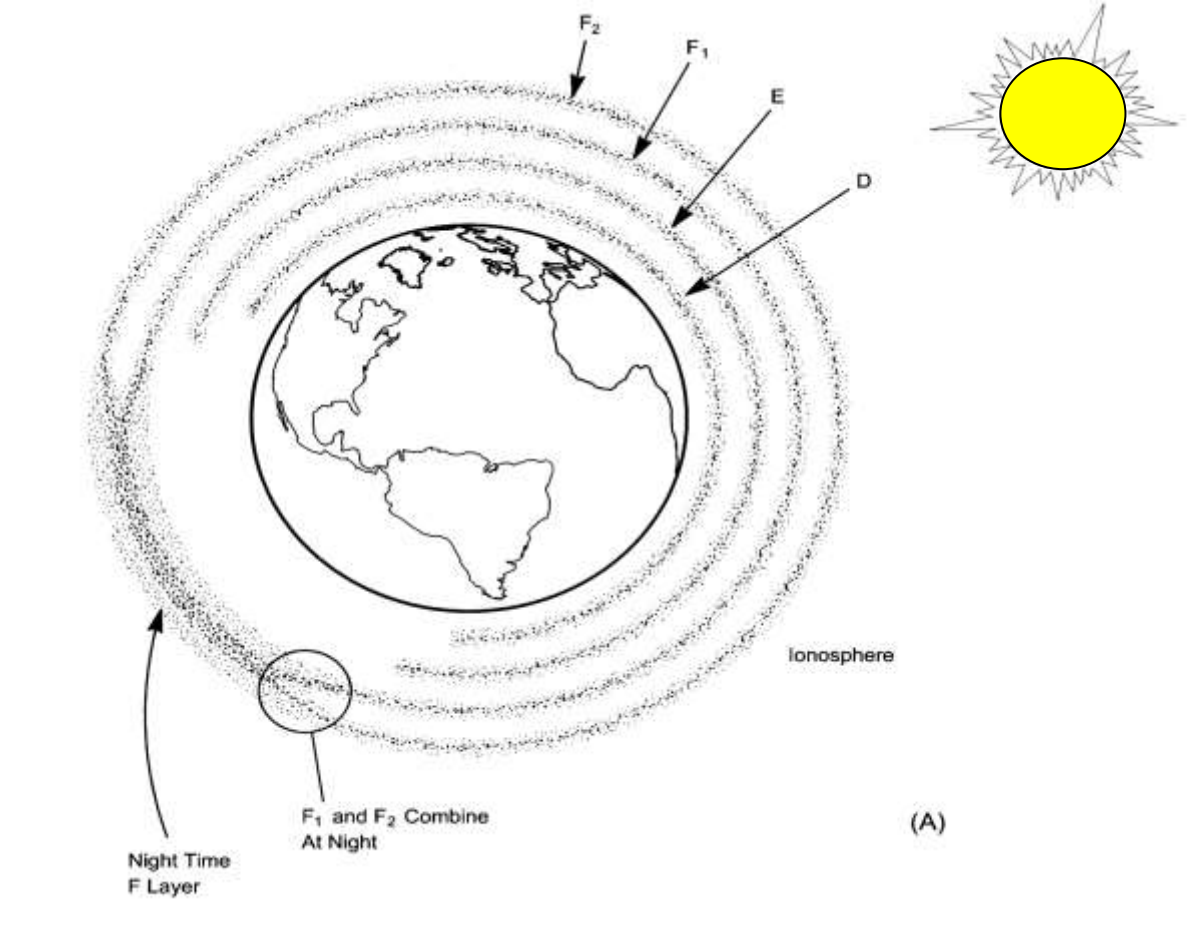
Daily variation of Ionosphere Layers



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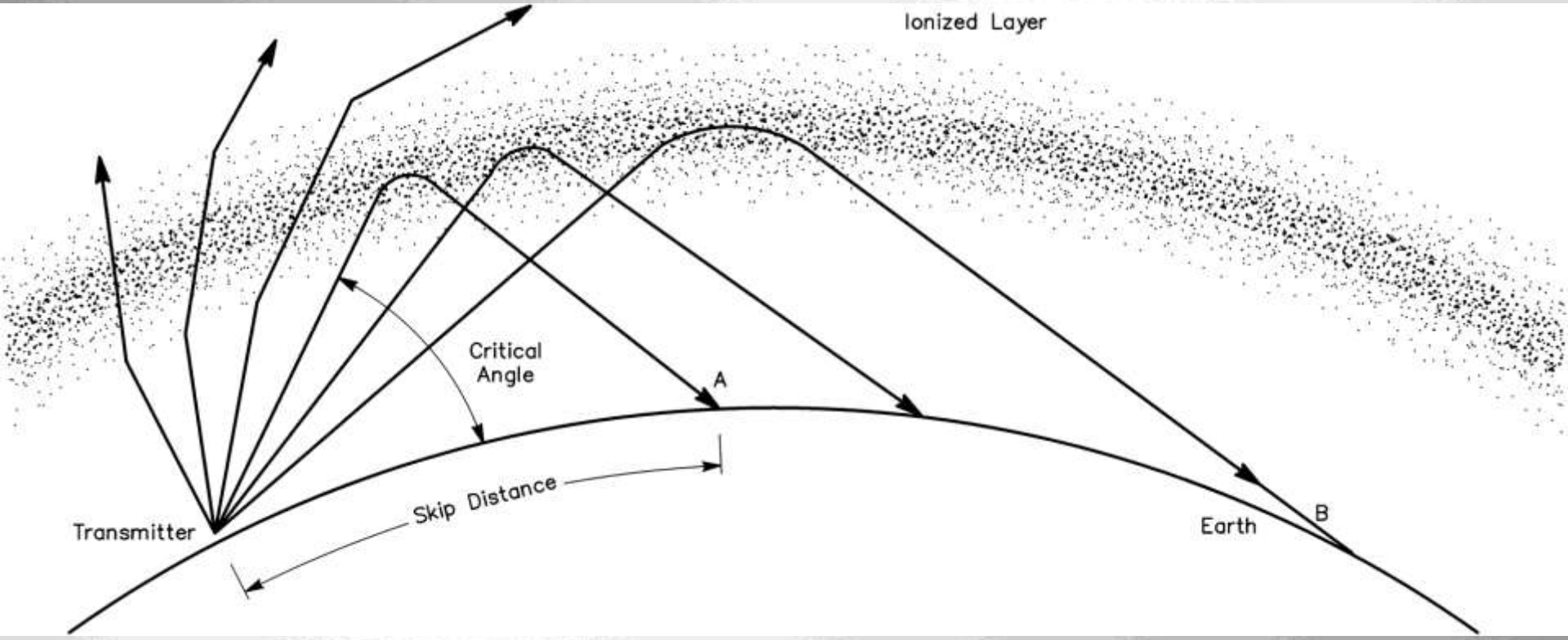
Ionospheric Reflection

Conduction by electrons makes the region act as an antenna to re-radiate or bend waves.

- Amount of bending depends on electron density
- Higher frequencies are bent less
- Frequencies too high to bend back towards earth pass though the layer
- Waves above a *Critical Angle* will not return
- The *Critical Frequency* is the highest frequency which will return at a vertical angle.

Critical Angle



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Ionospheric Absorption

The D and E regions have a high electron density due to more atmospheric gasses. Energy from waves in the D layer is absorbed by electrons.

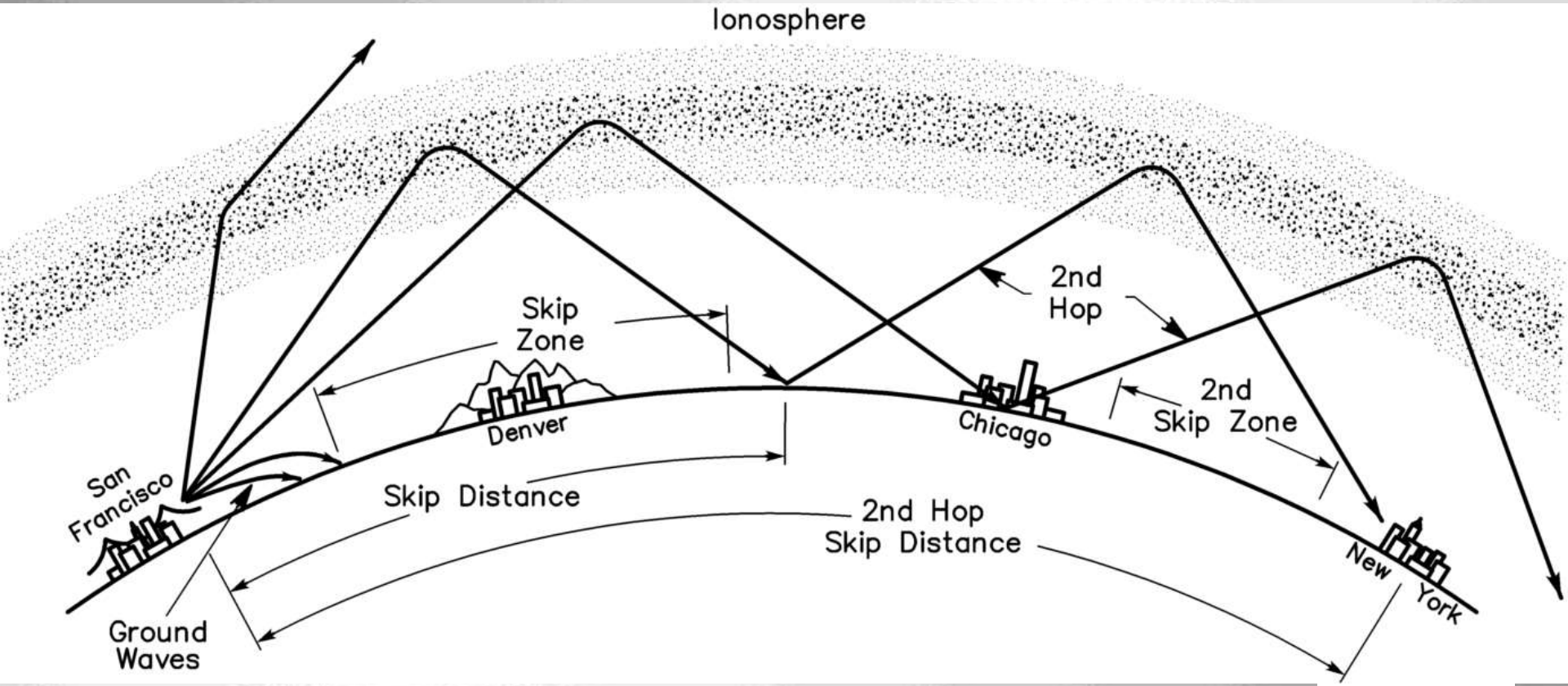
- D layer is densest at noon and disappears at night.
- D layer Electron activity is very absorptive, especially below 10 MHz.

Sky-Wave and Ground-Wave

Sky-wave signals are reflected by ionosphere with longest distance determined by F2 height and shortest distance determined by critical angle

- F2 hop is up to 2500 miles
- E hop is up to 1200 miles
- Multiple hops make longer distances
- Ground-wave is best at lower frequencies and over water.
- Between shortest sky-wave and longest ground-wave is skip zone

Ground Wave, Sky Wave and Skip Zone



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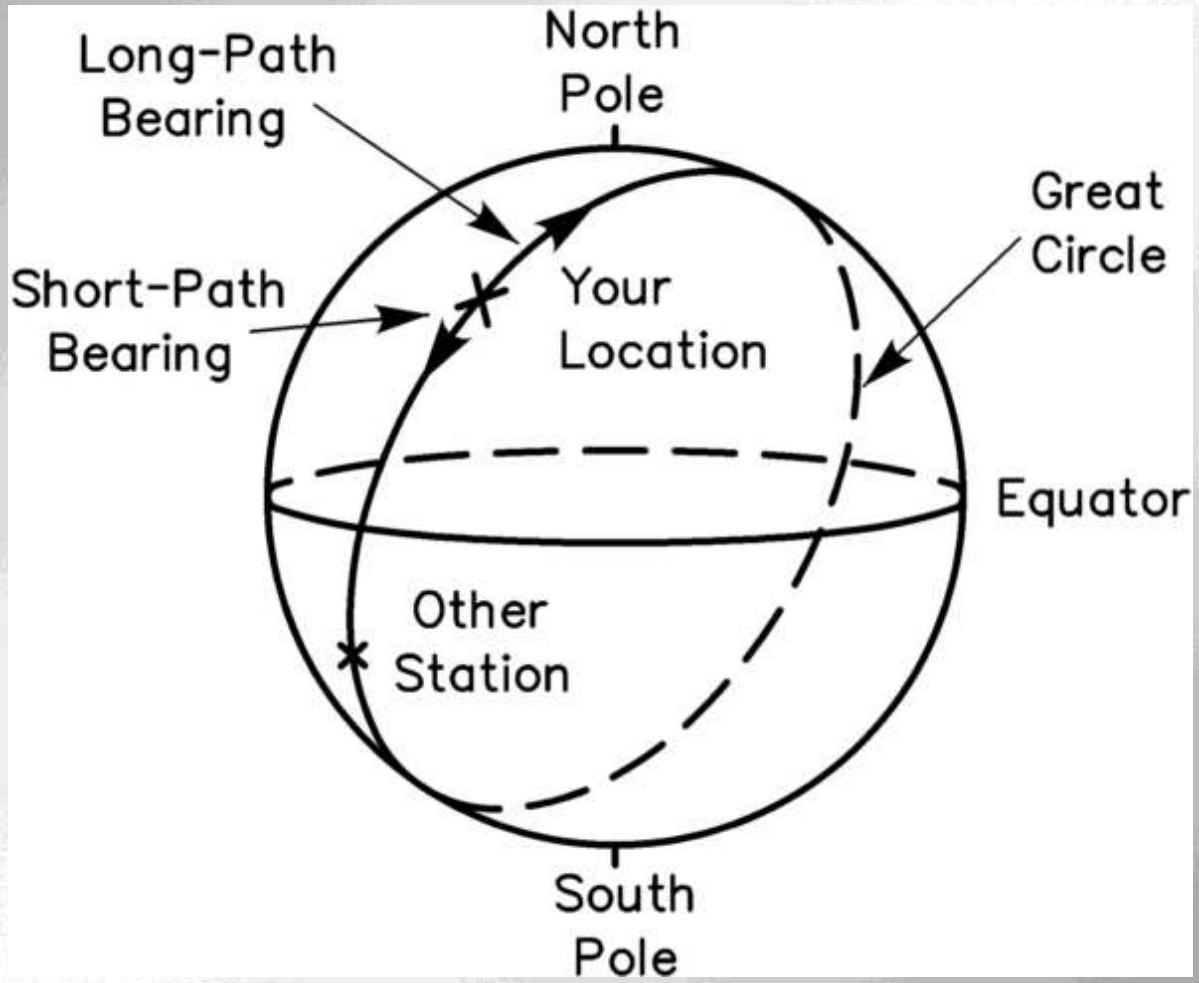
Long and Short Path



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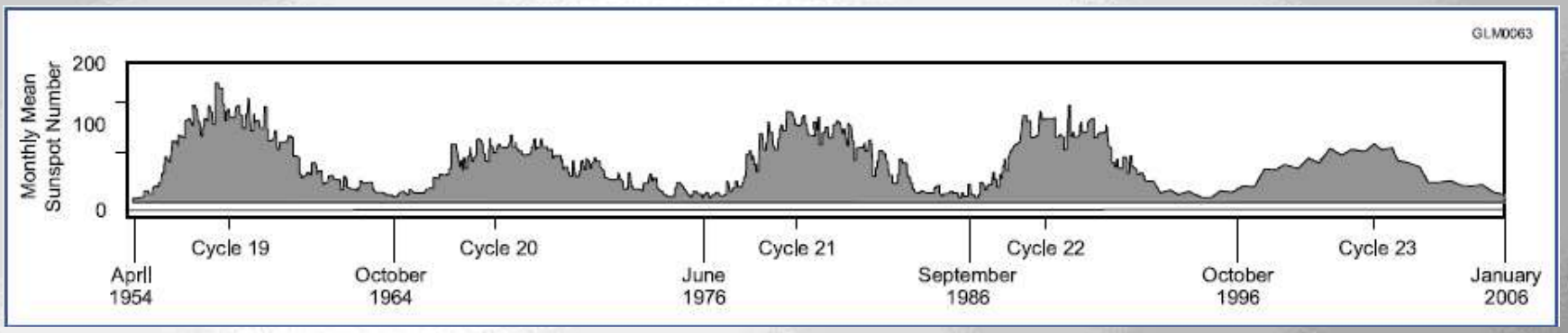
Sunspot Cycles

Ionosphere is caused by solar UV radiation which varies due to solar conditions, especially from sun spots.

Sunspot cycle is approximately 11 years from maximum to maximum



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Effects of Sunspot Activity

At cycle maximum

- Propagation improves above 10MHz and is open more often above 20MHZ
- In some previous cycles, 10 Meters was open world-wide all day and night. Also had 6 Meter DX openings
- HF bands below 10MHz are more disturbed, especially in daytime

At cycle minimum

- HF bands above 20MHz are dead most of the time
- HF bands below 10MHz have better propagation.

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Normal variations of solar output

Seasonal variations due to summer and winter

- More D layer absorption in summer so better propagation from evening to morning
- Daytime F2 layer is higher in summer
- Usually good propagation near Equinoxes
- 20Meter band is least affected by solar activity and has openings year-round

Variation due to sun's rotation

- Sun rotates once in 28 days so sunspots move
- Propagation conditions tend to repeat every 28 days

Solar Activity Indexes

- Solar Flux Index – indicates the level of 10.7cM radiation of the sun
  - Correlates to sun spot number
  - Less than 70 at sunspot cycle minimum
- K Index – 0 to 9; Short term stability of earth's magnetic field; Higher values mean poor conditions
- A Index – 0 to 400; Long term stability based on last 8 K values. A linear value to represent the logarithmic K values.

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Maximum and Lowest Useable Frequency

MUF and LUF can be predicted for a path and distance between two points for a takeoff angle

- Waves above the MUF will not be refracted back to earth
- Waves below the LUF will be completely absorbed
- Choose a frequency between the LUF and MUF
- When MUF is less than LUF, propagation is not possible for that path.

Solar Disturbances

UV and X-ray emissions due to Solar Flares reach Earth in about 8 seconds.

- Sudden Ionospheric Disturbances (SID) cause radio blackouts lasting seconds to hours
- More effect at lower frequencies
- Dark side of Earth not affected

Charged particles from Coronal holes and ejections reach Earth in 20 to 40 hours

- Geomagnetic disturbances
- Affects polar paths and causes distorted signals

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Scatter

Refractions from ionosphere scatter in many directions due to unevenness.

- Some of the signal is reflected back along it's path into the skip zone – back scatter
- Scatter signals may be wavering, fluttering and distorted.
- Forward scattering can occur at frequencies above MUF and into VHF by using high power and directional antennas.

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Near **V**ertical **I**ncidence **S**ky-Wave

NVIS allows communicating with nearby stations inside the skip zone and stations at ranges of few hundred miles by using a high take-off angle from the antenna.

- Use frequencies below the critical frequency
  - Below 4MHz at night; up to 7MHz daytime
- Use a horizontal antenna 1/8 to 1/4 wavelength above ground
- Higher power helps to overcome losses

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