Propagation of Radio Waves

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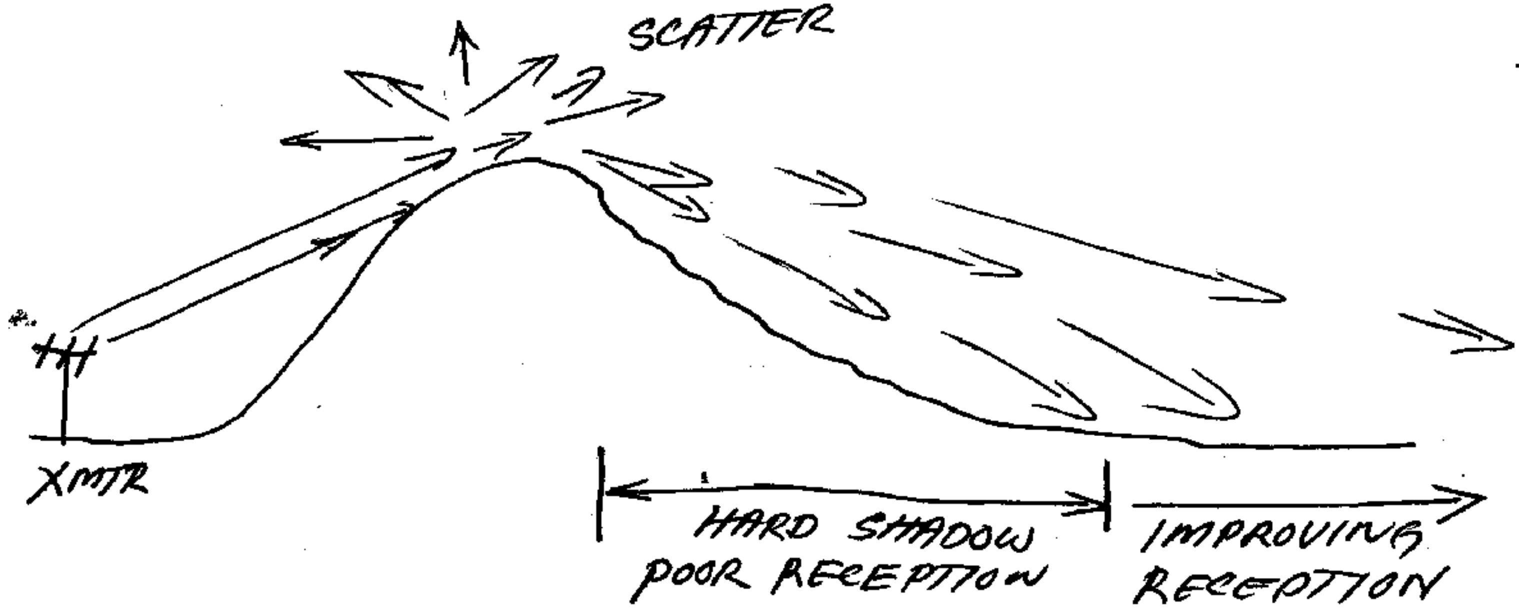
Basics of Propagation

- It seems like magic that with less power than a pen light, a signal can be heard around the world
- Scientifically it can be explained:
  - Any change in conductivity, permeability. or dielectric constant will bend or reflect a radio wave
  - Examples:
    - Rain
    - Clouds
    - Inversions
    - Earth/mountains
    - Trees
    - Snow
    - Meteors
    - Water
    - Aurora
    - Solar radiation

VHF and UHF Propagation

- VHF and UHF propagation is typically line of sight
- How can a signal get out of the hole here at Station 1 ?
  - Every object that has a different conductivity than air re radiates the signal



HF Propagation

- Most HF propagation is by reflections off the ionosphere
- Cycles that affect the ionosphere:
  - 11 year
  - Seasonal
  - 27 day
  - Daily
- Knowing the cycles can greatly enhance your operating pleasure

The Ionosphere

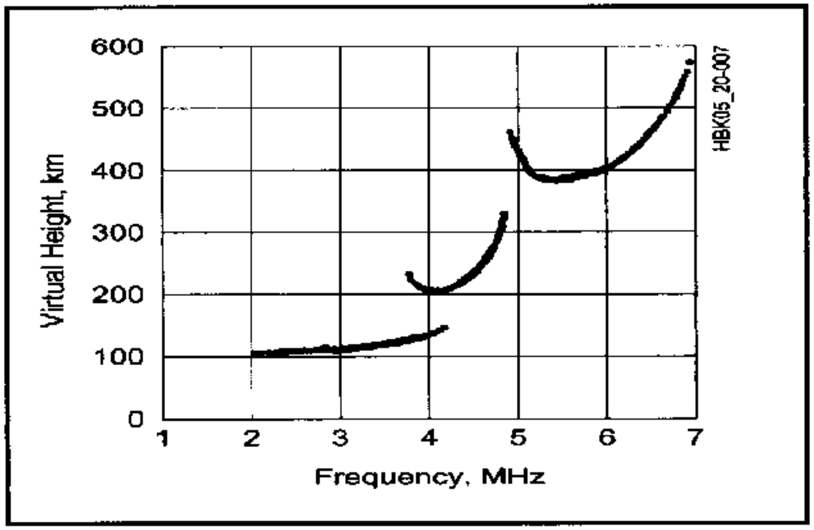


Fig 20.7—Simplified vertical incidence ionogram showing echoes returned from the E, F_1 and F_2 layers. The critical frequencies of each layer (4.1, 4.8 and 6.8 MHz) can be read directly from the ionogram scale.

Propagation of RF Signals 20.7

- The critical frequency is the highest frequency that can return a echo vertically from a layer of the ionosphere
- The smaller the angle of incidence, the better the reflection, the higher the frequency that can be reflected

Ionosphere

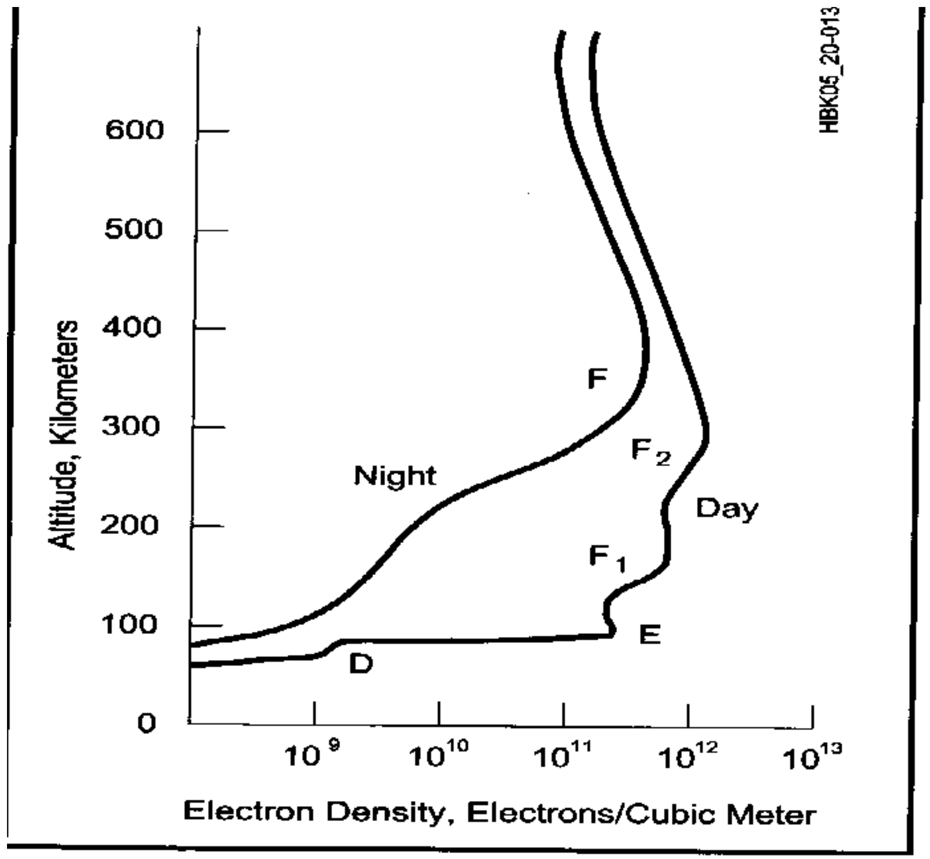
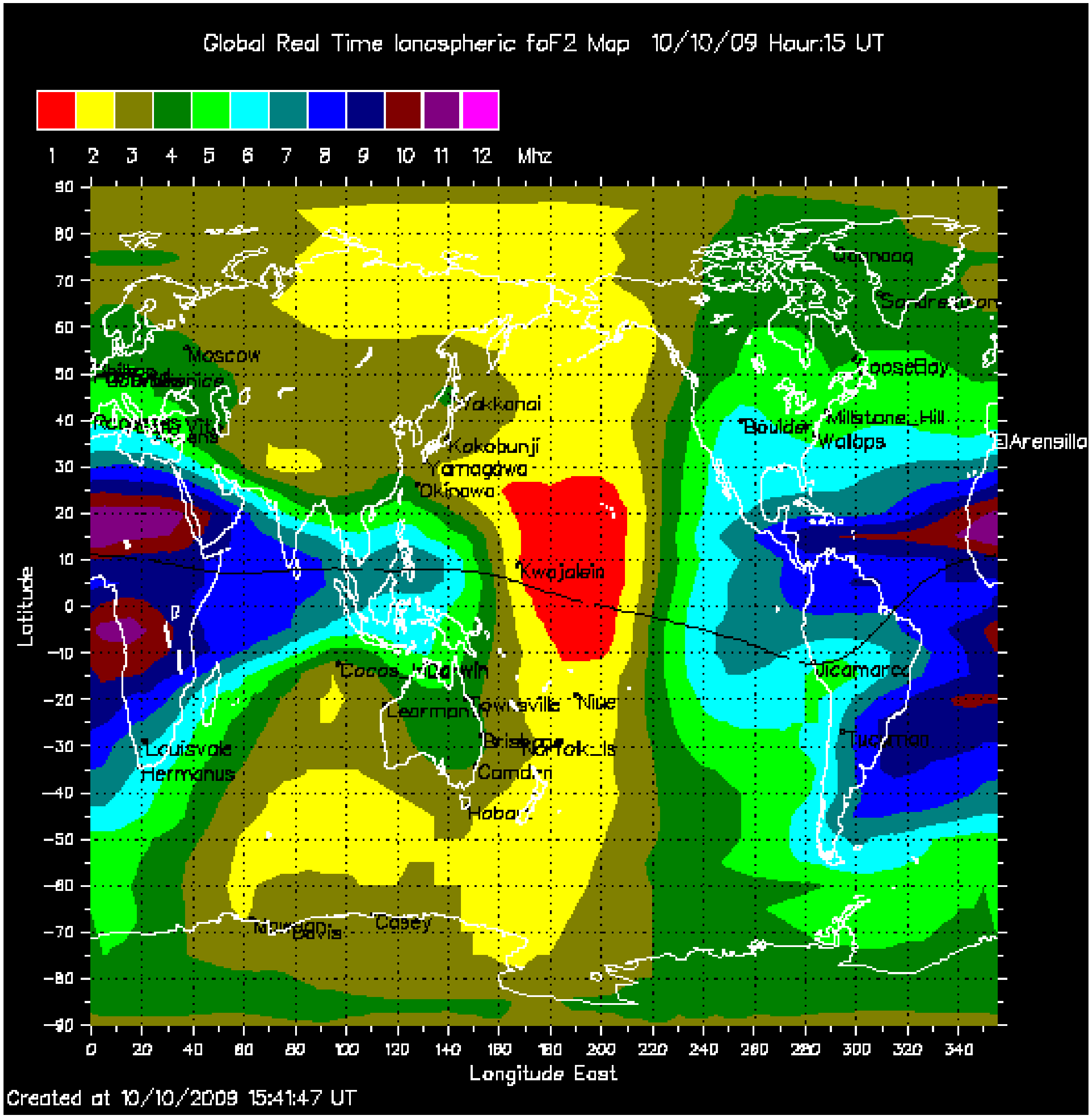
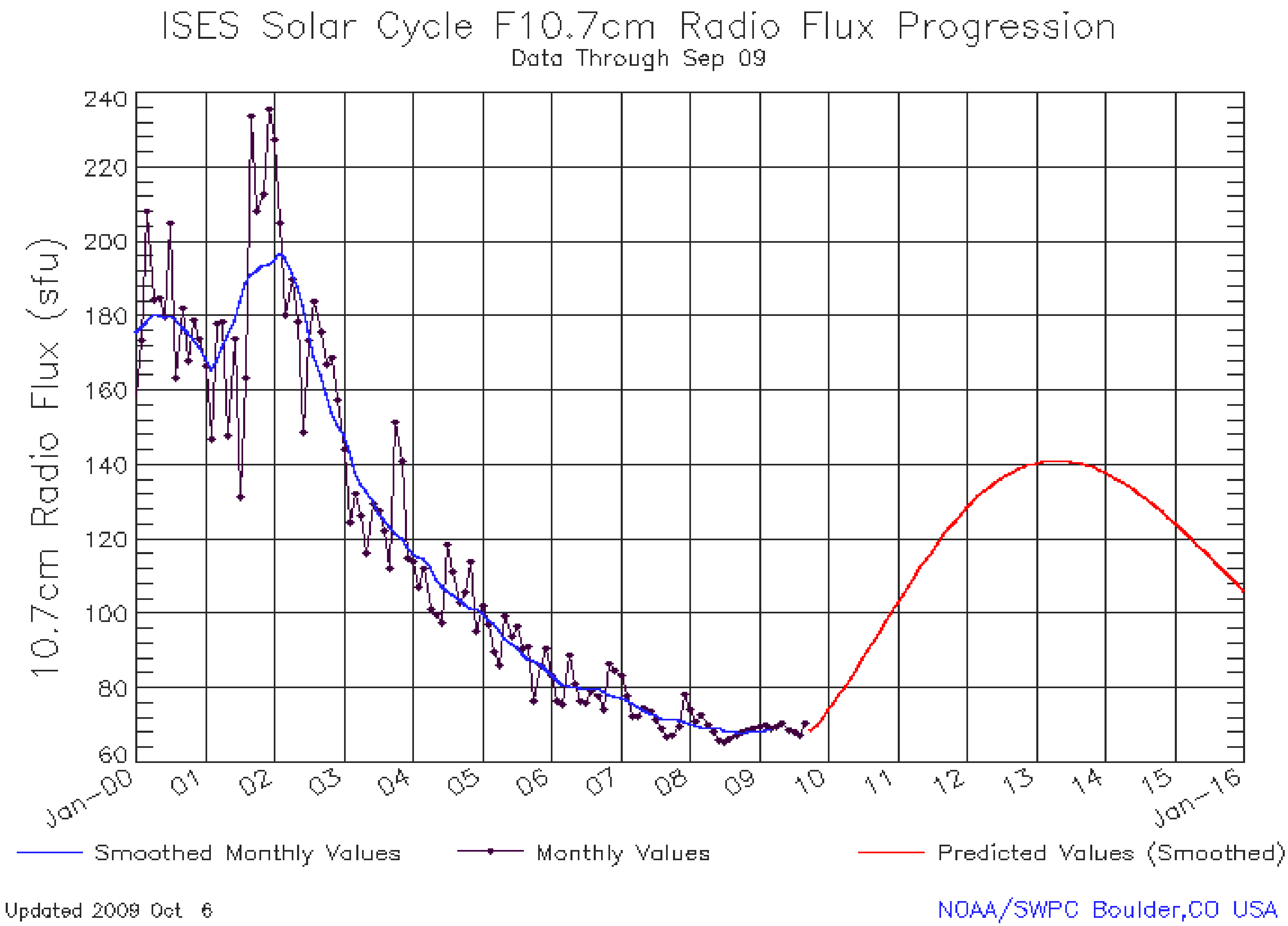


Fig 20.13—Typical electron densities for the various ionospheric regions. Not shown in the night profile is the electron density valley that is thought to be responsible for ducting on 160m.

Critical Frequencies



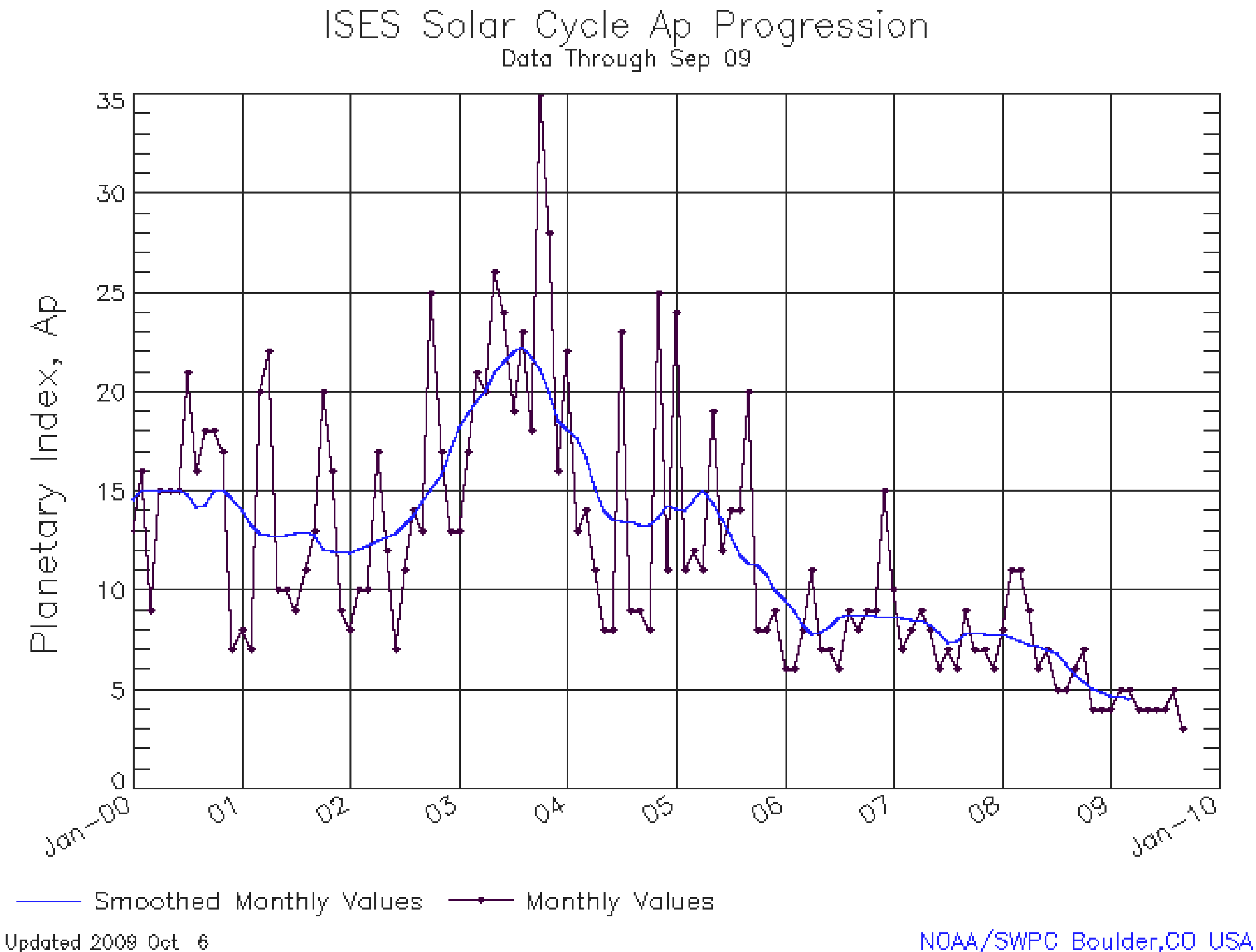
Night | Day



- Solar Flux is a measure of how strong the ionization will be
- Solar Flux can be directly related to the sun spot number
- Predicts the critical frequency

Maximum Usable Frequency MUF

- The critical frequency and the maximum usable frequency are related to each other
- The maximum usable frequency is highly dependent on the angle the waves hit the ionosphere
- Generally the absorption is low the closer one gets to the MUF
- Above the MUF the waves may be bent, but are not reflected back to earth.
- A quick way to check the MUF is to tune a general coverage receiver up the bands till no signals are heard

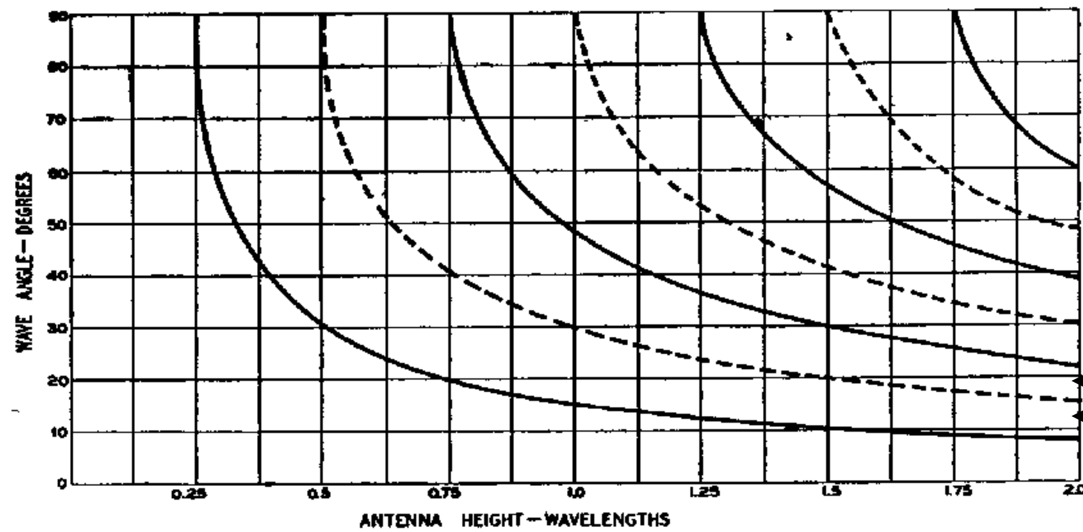


- Ap index is a measure of the geomagnetic activity
- It is a predictor of how much absorption will take place
- Affects the lower frequencies more than the higher ones
- Affects the poles more than the tropical regions
- Ap is related to the K index, but easier to understand

Antenna Height Affects Propagation (Arapaho Radio Club Field Day Experience)

Normal height

New height



Slope of hill=10 degrees

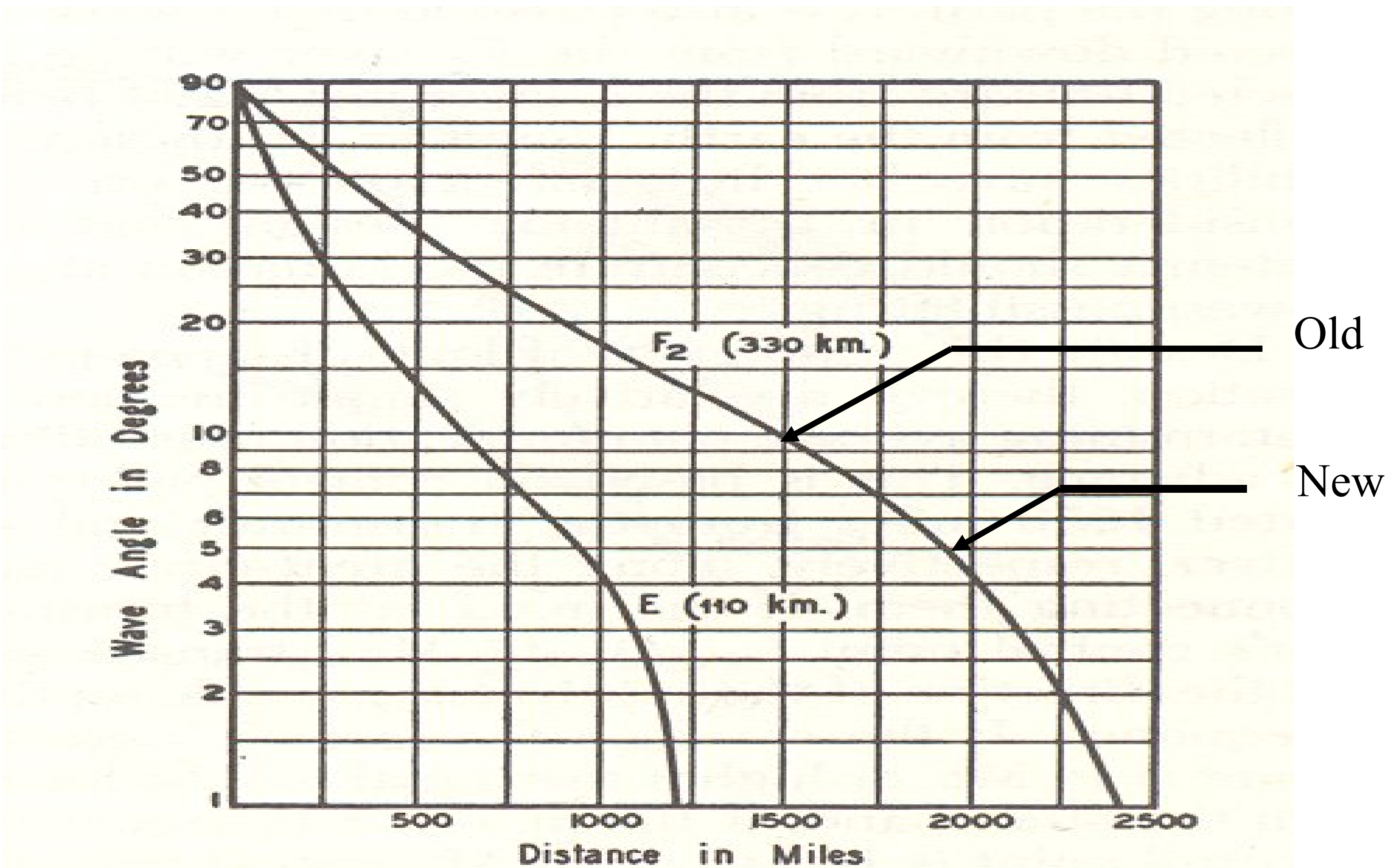
effective angles:

10 degrees

5 degrees

Fig. 2-44—Angles at which nulls and maxima (factor = 2) in the ground-reflection factor appear for antenna heights up to two wavelengths. The solid lines are maxima, dashed lines nulls, for all horizontal antennas and for vertical antennas having a length equal to an even multiple of one-half wavelength. For vertical antennas an odd number of half waves long, the dashed lines are maxima and the solid lines nulls. For example, if it is desired to have the ground reflection give maximum reinforcement of the direct ray from a horizontal antenna at a 20-degree wave angle (angle of radiation) the antenna height should be 0.75 wavelength. The same height will give a null at 42 degrees and a second maximum at 90 degrees.

Antenna Height Affects Propagation
Arapaho Field Day Experience



The new antenna height put our peak skip zone too far east

Winter and Summer

- The earth swings a total of 46 degrees with respect to the sun.
- This swing moves the critical frequency map several thousand miles north and south.
- The season of the year greatly affects the propagation

Propagation at High Noon

- Generally there is a drop in signal strength around noon for medium and long skip do to the absorption in the D and E layers especially on 20 meters
- Short skip with low antennas is typically good off the lower layers
- 10 meters can be good when the sun peaks between the stations
- North South contacts can be good on 10 meters

Sunrise and Sunset
Interesting times to be on the air!

- At sunrise and sunset the ionosphere is rapidly changing
- The change is most pronounced in the morning
- Unusual reflections can take place
  - Bending in the D and E layer can make for exciting DX even with a low antenna
  - Many times there is a significant boost in signal strength, especially when both stations are in the gray area of the globe
  - As the seasons vary, there will be a common time that you and a DX station will be experiencing a sun rise or sun set at the same time for most of the earth

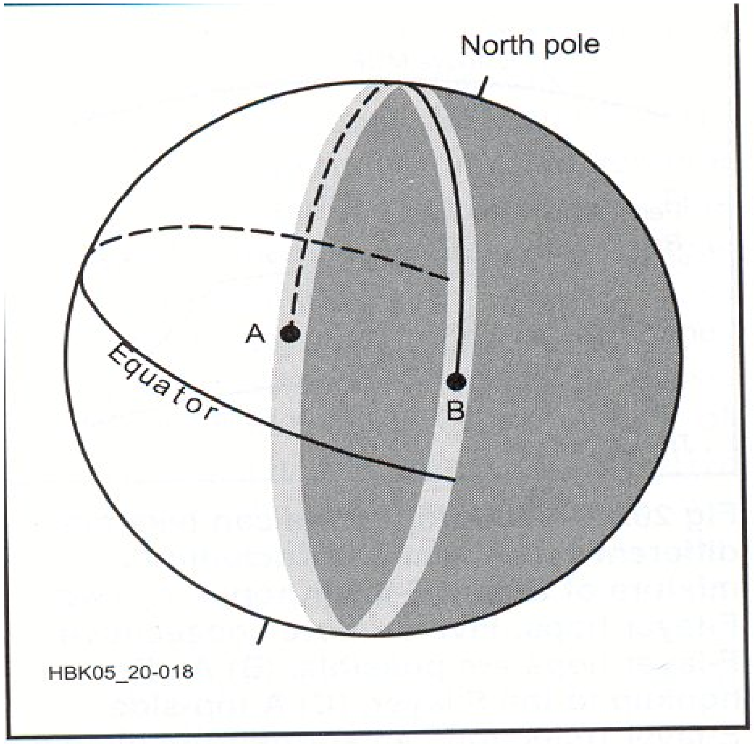
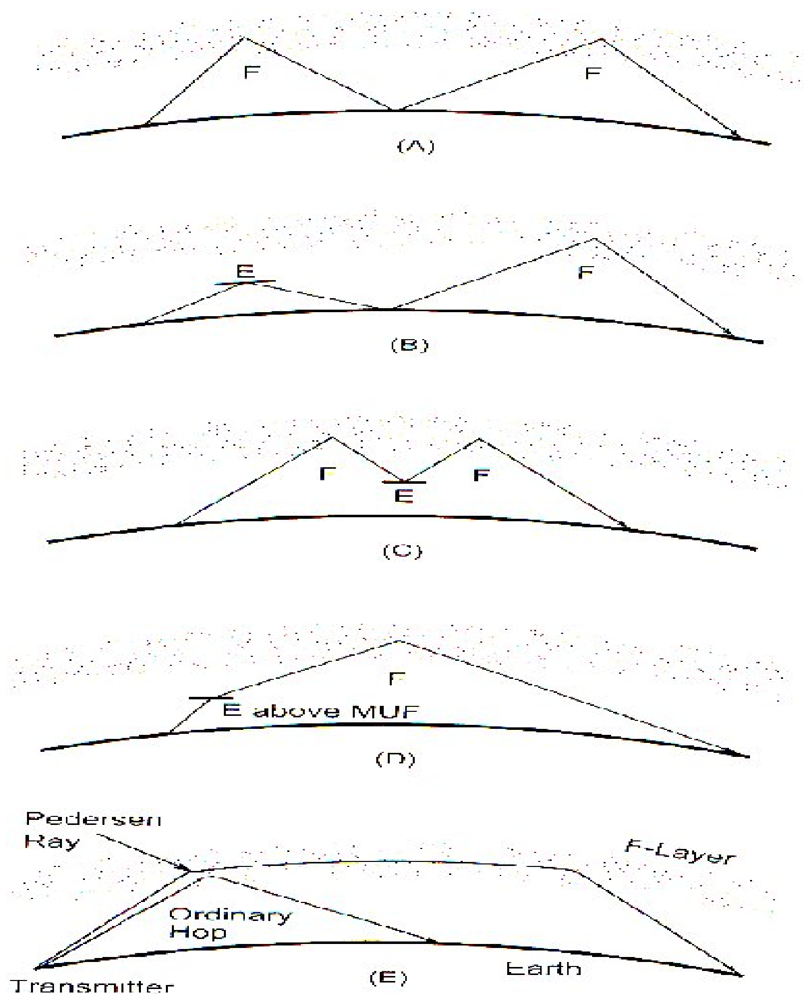


Fig 20.18—The gray line encircles the Earth, but the tilt at the equator to the poles varies over 46° with the seasons. Long-distance contacts can often be made halfway around the Earth along the gray line, even as low as 1.8 and 3.5 MHz. The strength of the signals, characteristic of gray-line propagation, indicates that multiple Earth-ionosphere hops are not the only mode of propagation, since losses in many such hops would be very great. Chordal hops, where the signals are confined to the ionosphere for at least part of the journey, may be involved.

Multi Hop and Other Long Distance Skip



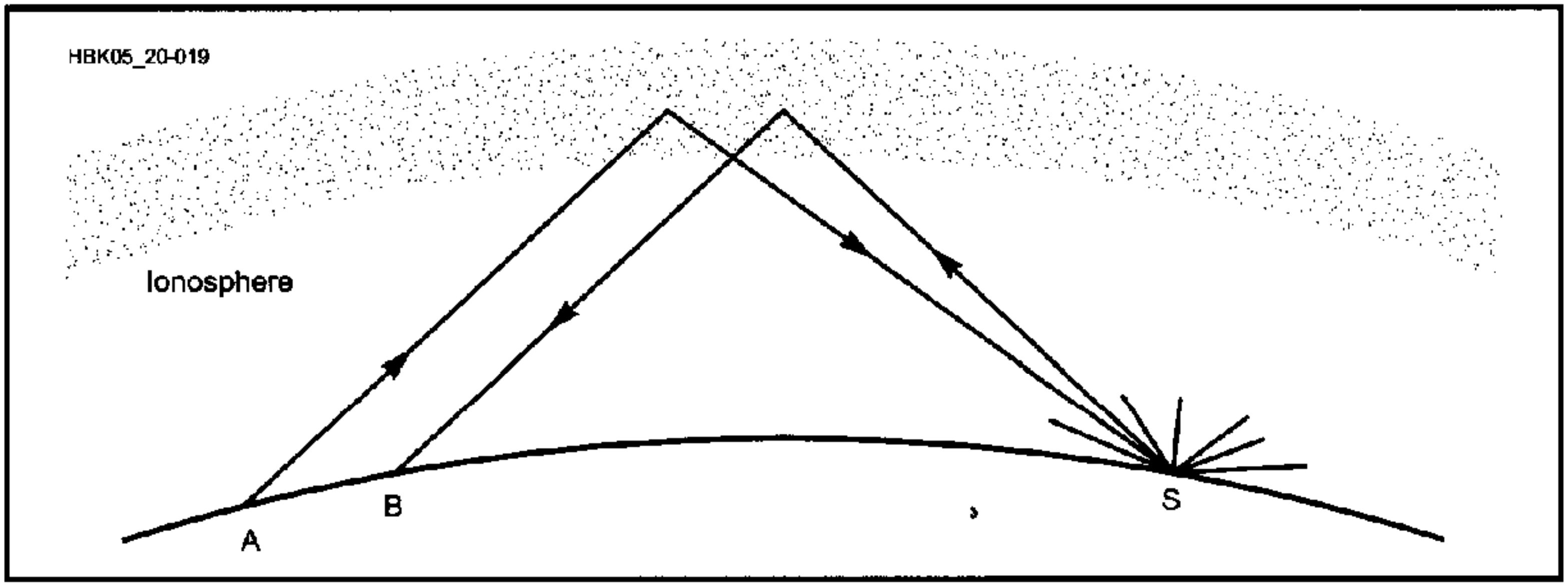
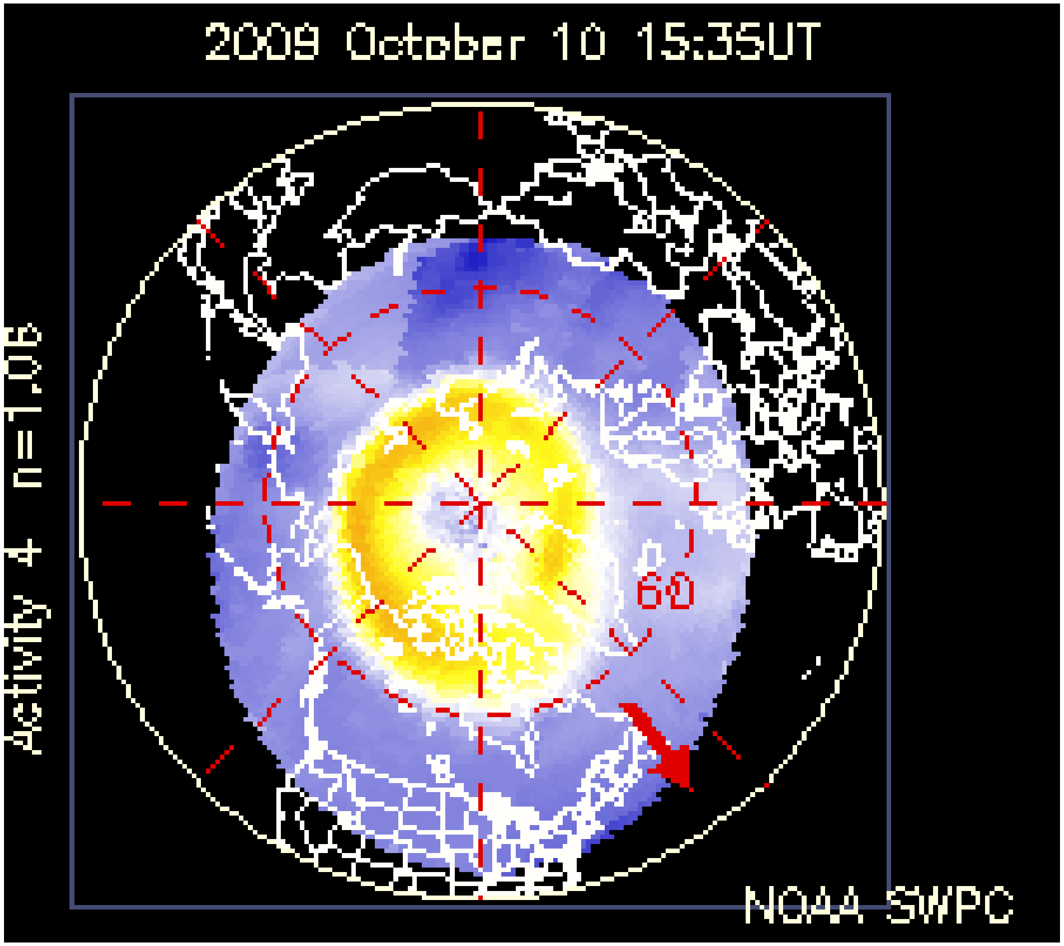


Fig 20.19—Schematic of a simple backscatter path. Stations A and B are too close to make contact via normal F-layer ionospheric refraction. Signals scattered back from a distant point on the Earth's surface (S), often the ocean, may be accessible to both and create a backscatter circuit.

Aurora



- Aurora scatters the signals
- Creates a hollow sound like talking into a tube
- Can make for interesting propagation over the pole

Questions