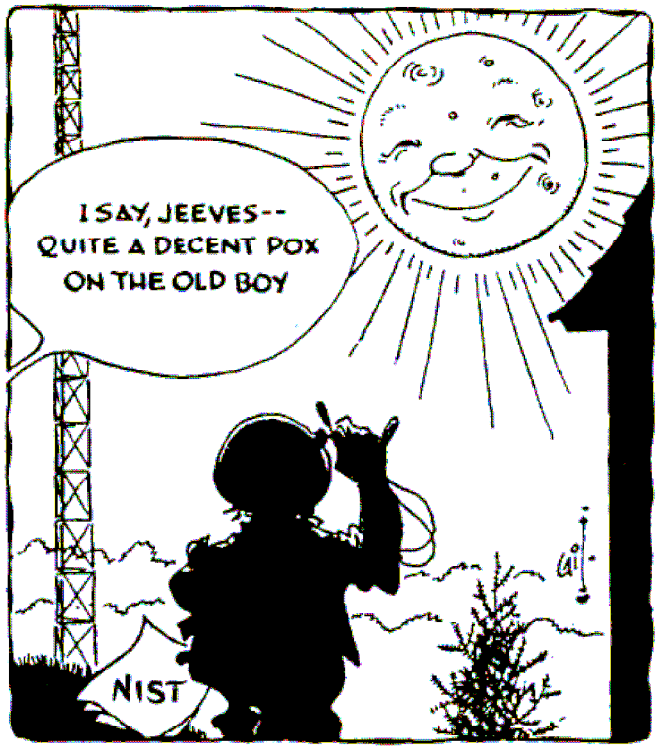
HF Propagation by KD1F



The sun has a large effect on communications on Earth. Solar flares, as well as sunspots, can make long-distance communications possible – or impossible.

The Atmosphere

- Troposphere: Height between 0 and 7 miles. Clouds form here, temperature decreases rapidly with altitude.
- Stratosphere: range from 6 to 30 miles. Gases spread out here, region of the jet stream.
- Ionosphere: Derives its name from the term ion, which is a free electron. 30 to 400 miles high. 1% of the earths atmosphere and solar radiation creates ions. Most interesting area for Hams because of various aspects of the HF radio wave propagation.

Propagation

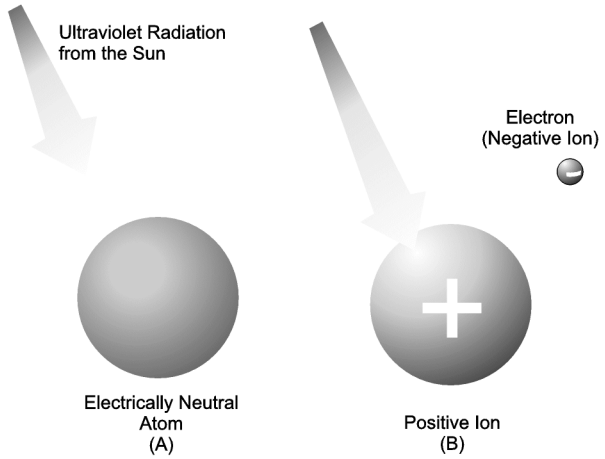
- Propagations depends on the following characteristics:
  - Which Bands (frequencies) ?
  - Daytime or Nighttime
  - Understanding these fundamentals together with experience will direct you to what time and frequency to use for and given situations.
- In Theory, radio waves should not behave this way.
  - Early Physicists had it line of sight
  - Marconi experimented and things did not behave the way they should.
- Because of Propagation Frequencies are Regulated by ITU (International Telecommunication Union) and FCC.

Ground Wave Propagation

- Travels along the Earth's surface.
- AM broadcasts use Ground Propagation during the day.
- Ground Wave works best on low frequencies.
- Short distance contact on 80 meters is a good example
- AM broadcast approximately 100 miles during the day.

Sky-Wave Propagation

- Ions are produced by the upper atmosphere as it is being bombarded by ultraviolet radiation and others by the sun.
- Atoms have electrons knocked off thus forming positive and negative ions
- This is called ***Ionization*** and this region is called the ***Ionosphere*****.**

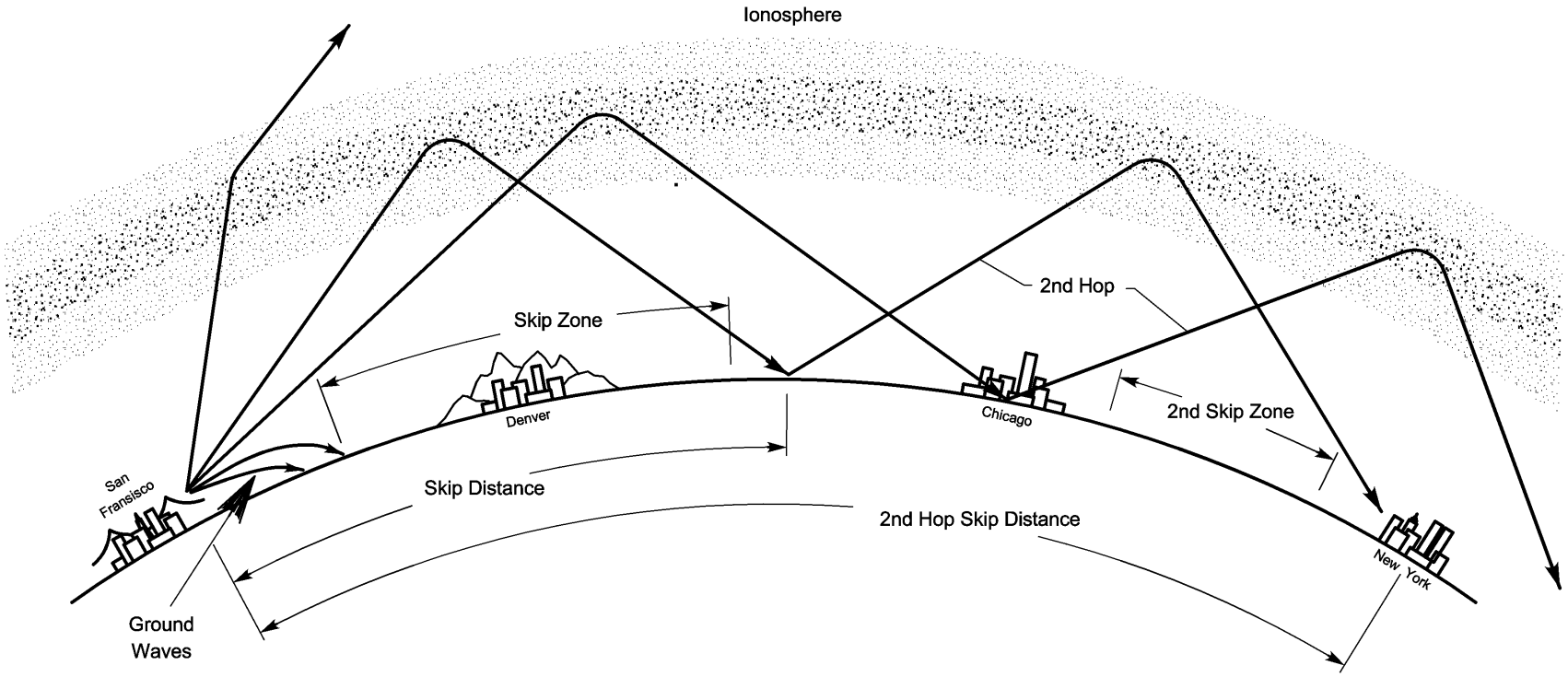


Sky-Wave Propagation Con't

- The Ionosphere can refract or bend radio wave.
- Those bent enough return to Earth.
- The others travel off into space.
- The highest frequency where a signal is reflected back to Earth is call the ***Critical Frequency.***
- Ham Radio contacts up 2500 miles are possible with one skip off the ionosphere.
- Worldwide communications use several skips or ***multi-hops*** when conditions are right.

Sky Wave Propagation – Con't

- How Radio waves travel into the ionosphere



Sky-Wave Propagation Con't

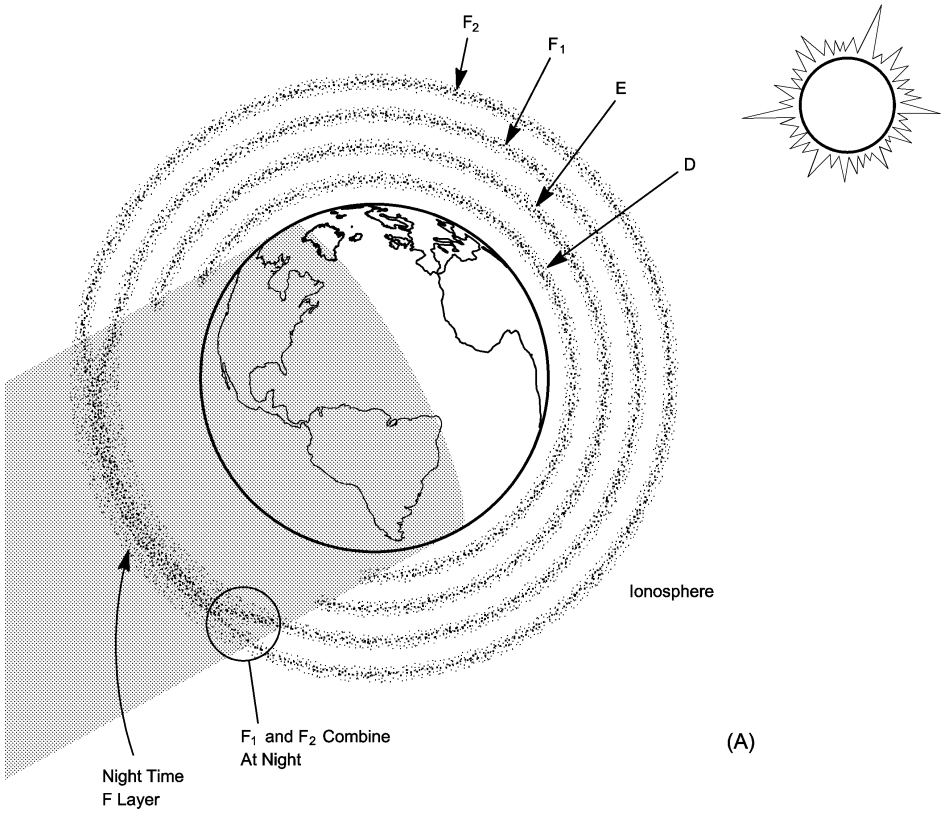
- Two factors determine sky-wave propagation:
  - The *frequency* in use
  - The level of *ionization*
- The higher the frequency the less it is bent
- The highest usable frequency to a desired location on Earth is called the ***maximum usable frequency*** **or (MUF)**
- Radio waves that extend beyond the horizon by refraction are called ***sky waves***.

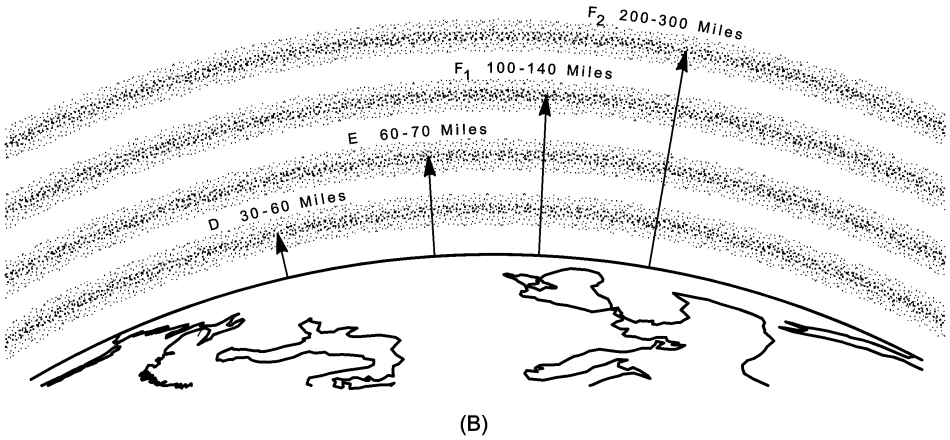
Sky Wave Propagation Con't

- Ionization of the ionosphere is result of UV radiation from the Sun
- Greatest during the day and summer
- Changes through the day, season and year.
- Radiation intensity is closely related to ***sunspots.***
- Sunspots vary in number and size over an 11 year cycle.
- More sunspots means more ionization. As result, the MUF is higher.
- Less sunspots, MUF is lower.
- Skip distance has both a minimum and maximum range
- ***Skip Zone*** is the dead zone.

Regions in the Ionosphere

- Ionosphere consists of several regions.





D Region

- The ***D Region*** is the lowest region of the ionosphere affecting propagation.
- Altitude is between 35 and 60 miles above Earth
- At noon is reaches maximum level of ionization
- At sunset is disappears.
- It is ineffective in refracting HF signals
- Major effect is to absorb energy from radio waves. More ionization, more absorption.
- Absorption affect is increased on lower frequency spectrum like 40, 80 or 160 meters.
- Dissipates in the evening.

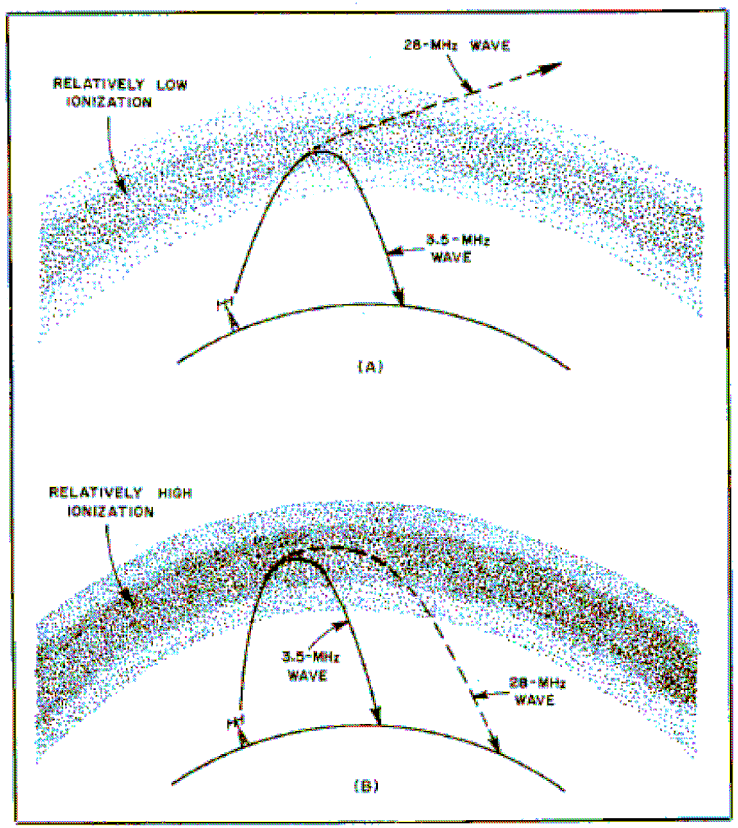
E Region

- The ***E Region*** Altitude is about 60 to 70 miles above Earth
- Ionization does not last very long
- Acts like the D Region in that it is a daytime phenomena only.
- Can refract signals to a maximum distance of about 1250 miles
- Dissipates in the evening.

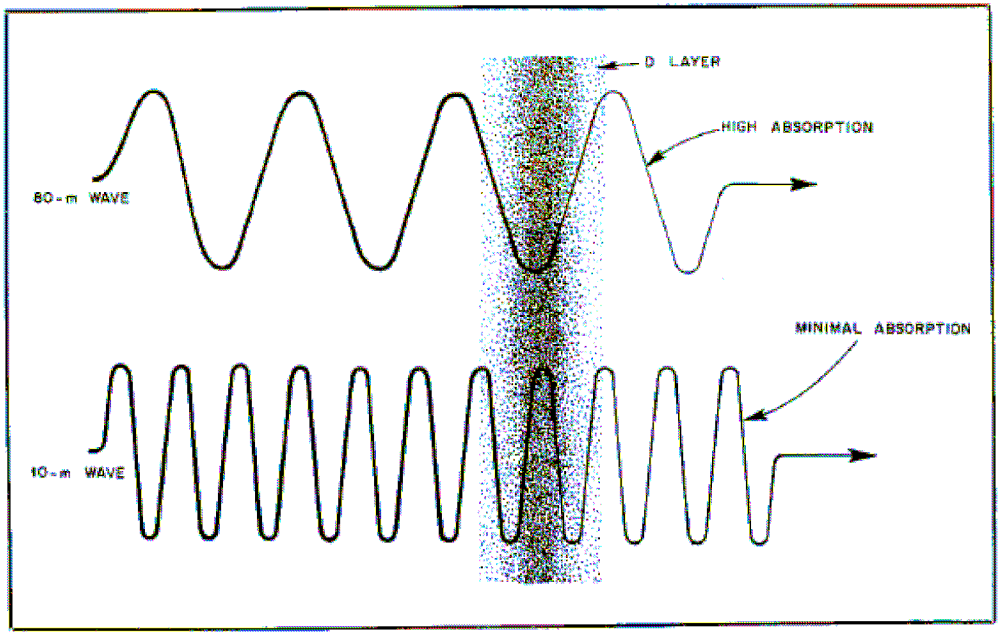
F Region

- This ***F Region*** is most responsible for long-distance amateur communication.
- Very Large. Ranges from 100 to 310 miles above the Earth.
- It does not dissipate during the night.
- At maximum splits into two layers, F1, F2
- The F1 layer effects are similar to E Region.
- Forms a single layer at night F2
- One hop transmission is about 2500 miles

Examples of MUF & Absorption



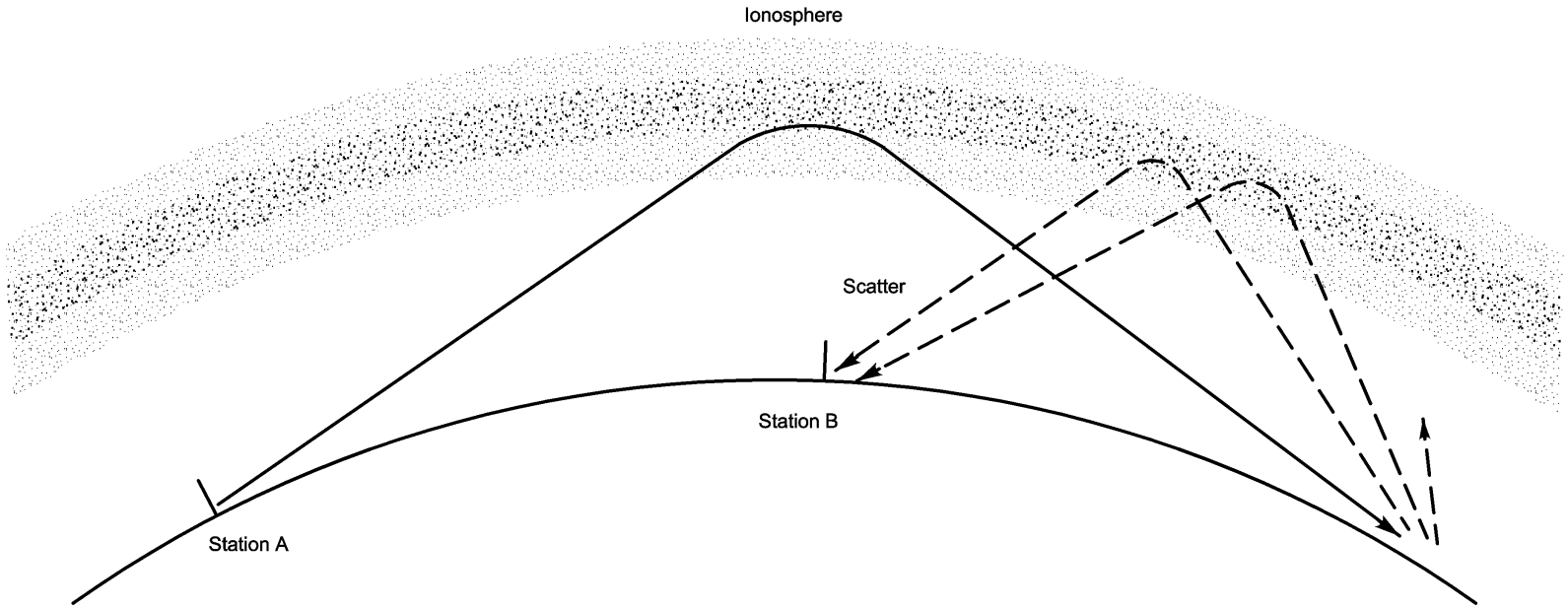
In A, the ionization is insufficient to refract the 28 MHZ wave back to earth: but the level is high enough for the 3.5 MHz signal. In B, there is sufficient ionization to refract the 28 MHZ.



All conditions being equal, a lower frequency signal will undergo greater D-layer absorption than a higher frequency.

HF Scatter Mode

- Scattering or Backscatter is weak and subject to echoes and distortion. Under ideal conditions it is workable.



Understanding Solar Indices

- **The Basic Source**
  - **WWV** broadcasts solar information and propagations forecasts**.**
    - 18 minutes after each hour
    - On 2.5, 5, 10, 15 and 20 MHZ
- **Data Broadcasted**
  - Solar Flux
    - An index of solar activity based on sun-noise measurements made daily on 2800 MHZ. Solar flux correlates will with ionization levels in the ionosphere, so it's a good indicator of HF propagation conditions.
  - K Index
    - Is a measure of the state of the geomagnetic field. The K index is measured on a scale of 0 to 9, where 0 is the quietest and 9 is the most disturbed; the lower this number, the better condition. This is updated every 3 hours. Note this is not a forecast.

Understanding Solar Indices (con't)

- **Data Broadcasted (cont)**
  - A Index
    - Is an average value of geomagnetic activity over 12 hour period, based on the K index.
    - The A Index is expressed on a scale of 0 to 400.
    - Forecasts a second number for the next 12 hours. The lower the number, the better.

Table 1
Relationship of the A and K Indexes

K	*A*
0	0
1	3
2	7
3	15
4	27
5	48
6	80
7	140
8	240
9	400

Source: *A User's Guide to the Space Environment Services Center Geophysical Alert Broadcasts*

Table 2
Geomagnetic Activity Category versus A and K Indexes

Category	*A-Index Range*	*K-Index Range*
Quiet	0-7	Usually < 2
Unsettled	8-15	Usually < 3
Active	16-29	Up to 4
Minor storm	30-49	Mostly 4-5
Major storm	50-99	6 or higher
Severe storm	100-400	7 or higher

Source: *A User's Guide to the Space Environment Services Center Geophysical Alert Broadcasts*

Interpreting the Numbers

- They represent the current and future forecast of the propagation conditions.
- Best when Solar Flux is high and the A and K Indexes are near zero.
- A high Solar Flux during the peak of the solar cycle is near or above 200.
- High A and K indices indicate flares and lots of absorption. In addition they deplete ionization the the F2 layer and increase absorption in the D layer.
- Remember that the numbers are a forecast and can change for the better or worse.
- 10 Meters is the most sensitive to changing conditions.
- 160, 80, 40 and 30 Meters are relatively insensitive to solar flux, but rely on low steady A and K indexes.

Sources of Propagation Forecast

- Bulletins from the ARRL.
- Listen to WWV at 18 minutes after each hours on 2.5, 5, 10, 15 and 20 MHz.
- Call Boulder, CO via telephone at (303) 497-3235 for recorded message.
- Connect to a DX Packet Cluster node. Type the command SH/WWV *nn.*
- *Remember conditions vary as a result of varying levels of ionization.*

What are Conditions Now?

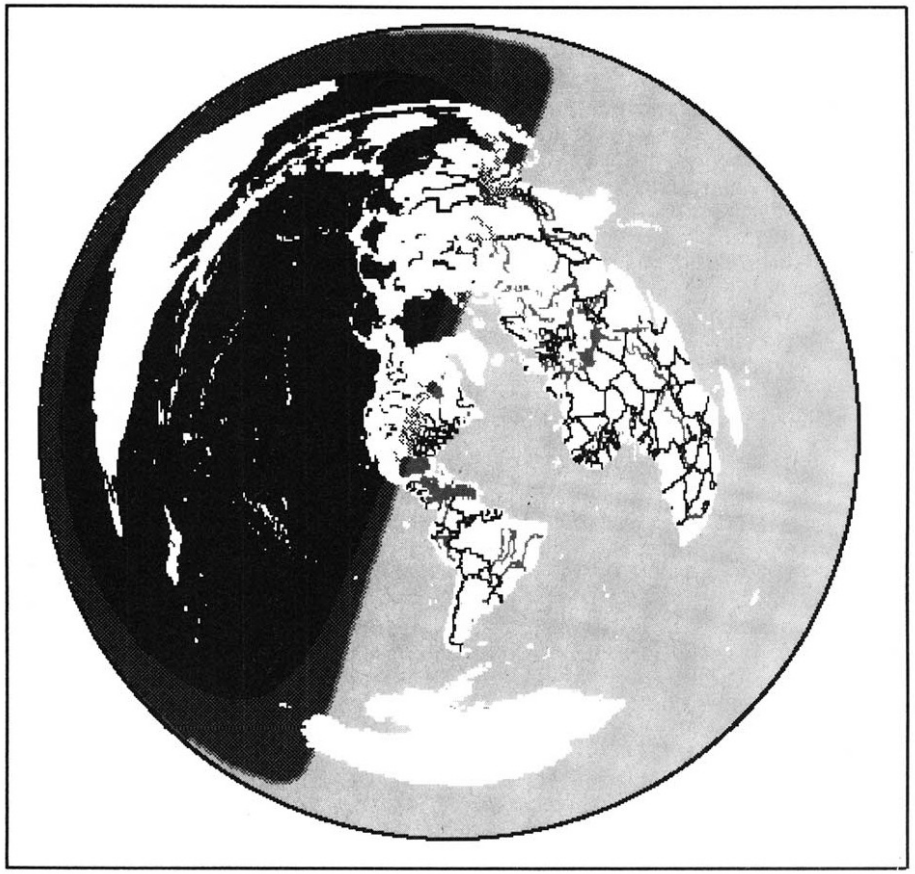
- Listen to WWV. Give you and idea of MUF.
- Northern California DX Foundations has 9 beacon stations on 14.1 MHz.
  - One on each continent.
  - Each operates for 1 minute in rotation.
  - Sends call and transmitter power.
  - Reduced power in seqeunce from 100 to 10 to 1 watt.
  - Within 10 minutes you can determine the 20 meter band conditions.
- Many other beacons operating on other bands.
  - Check ARRL Operating Manuals for a list of beacons.

Other Factors Effecting Propagation

- 11 Year Solar Cycle
  - Peak you can work the world on 1 watt on 10 meters.
  - Misconceptions at the low period of the Cycle. They are not shut down.
- Daylight and Darkness
  - MUF changes
- Summer and Winter
  - Summertime Propagation
    - Upper Bands are open later in the day, even into the evenings.
    - Over the pole has high absorption, better on 40 Meters.
    - Transequatorial paths are great, especially on 10 meters.
  - Winter Propagation
    - Upper bands close early, sometimes never open
    - Tilt of the earth has North Pole in total darkness
    - Over the pole (northern hemisphere) excellent propagation to opposite sides of the world.
    - Reveres in the Southern Hemisphere.

Grey-Line Propagation

- Sunrise/Sunset line is know as the *Grey Line or Terminator*.
- Some of the most exciting paths happen along the *Grey-Line*



Grey-Line Propagation (cont)

- MUF are rising rapidly on the sunrise side and still high on the sunset side.
- D region has not yet been energized on the sunrise side and rapidly dissipating on the sunset side.
- Results: Stations in the twilight zone can communicate with stations at any other locations within the twilight zone just about on any HF Band.
- Can last as long as one to two hours on the 20 meter band.