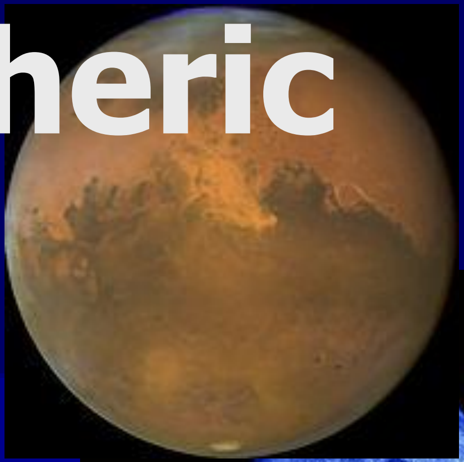
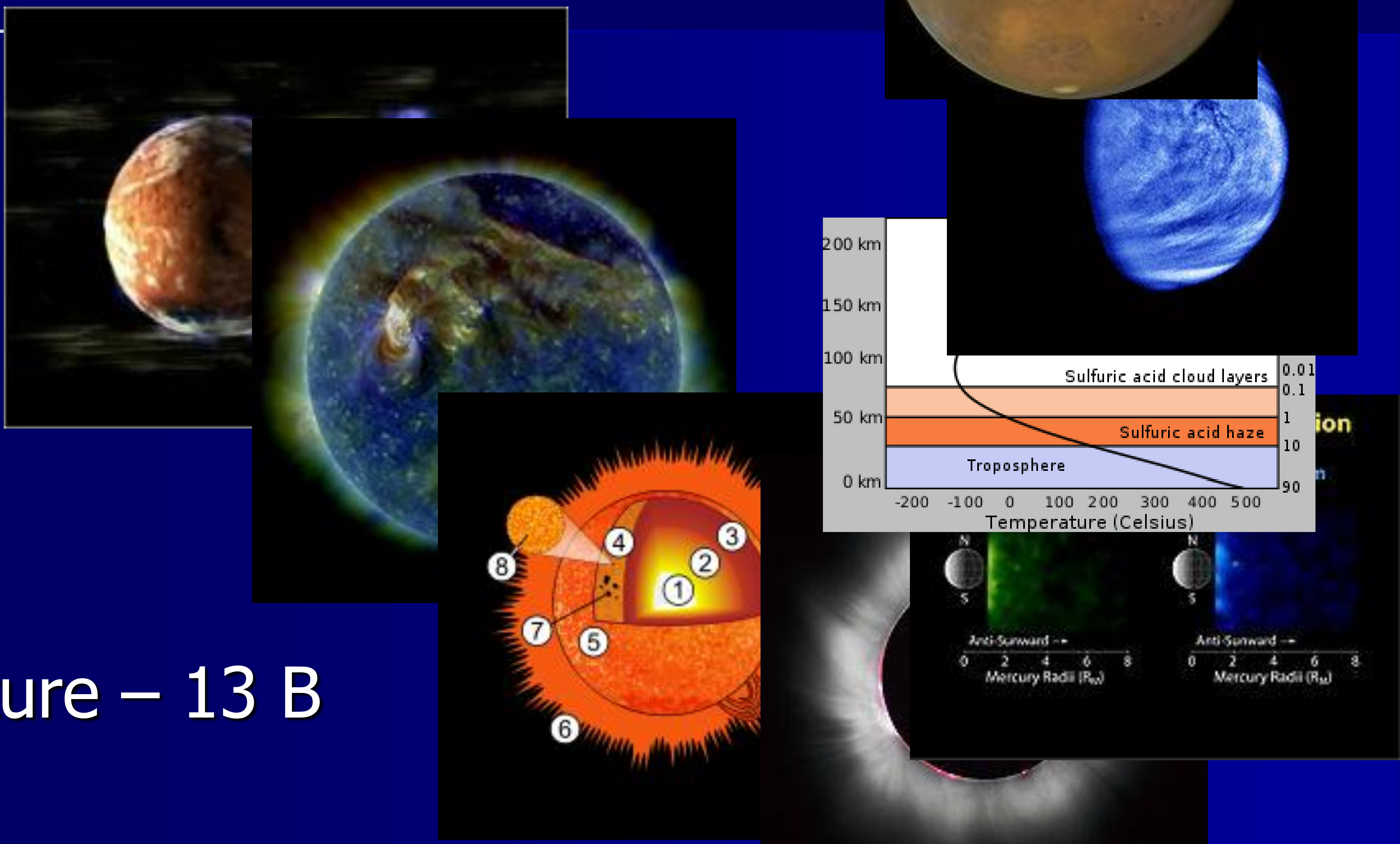
Space Physics

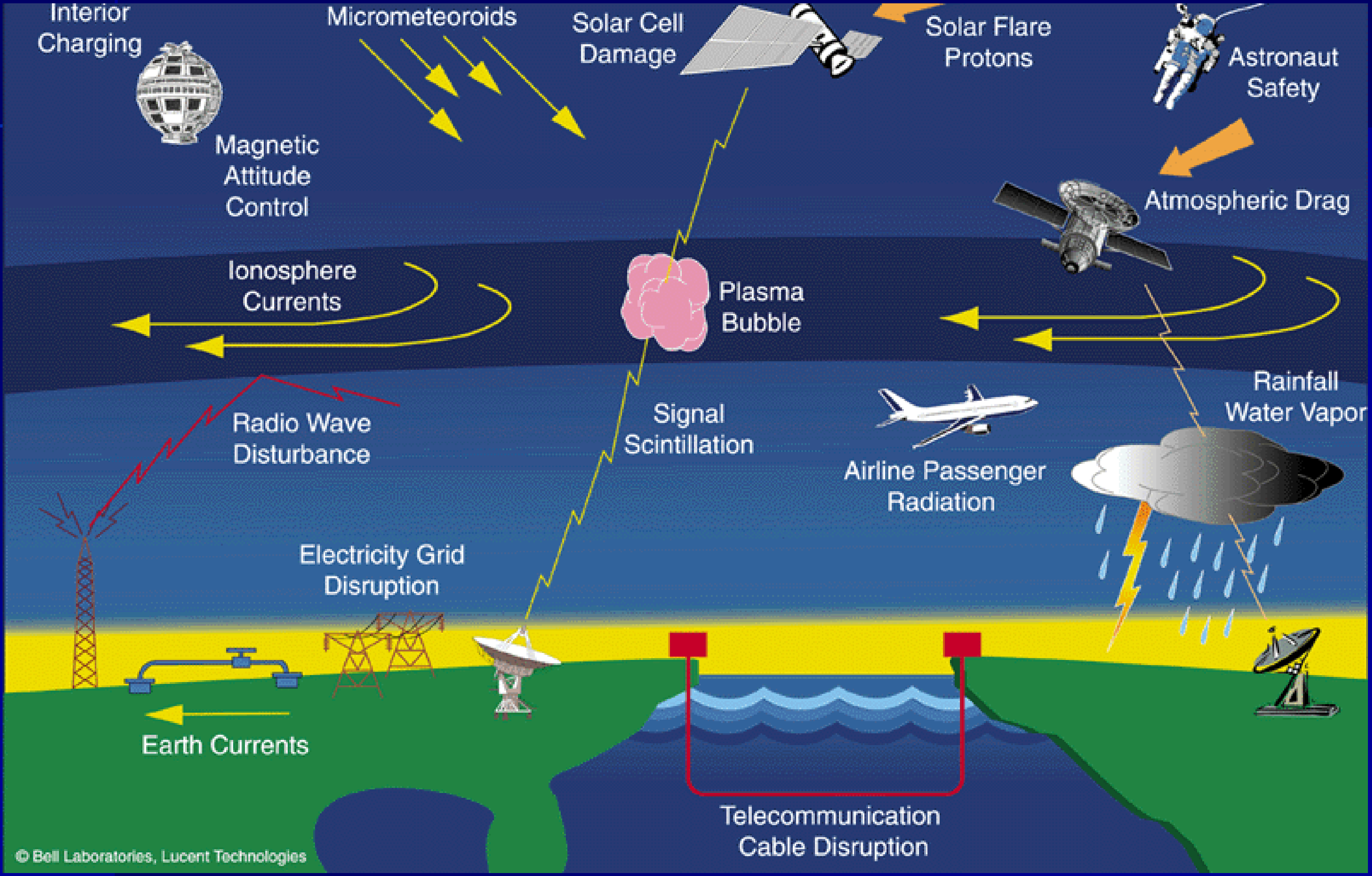
Space & Atmospheric Physics





Lecture – 13 B

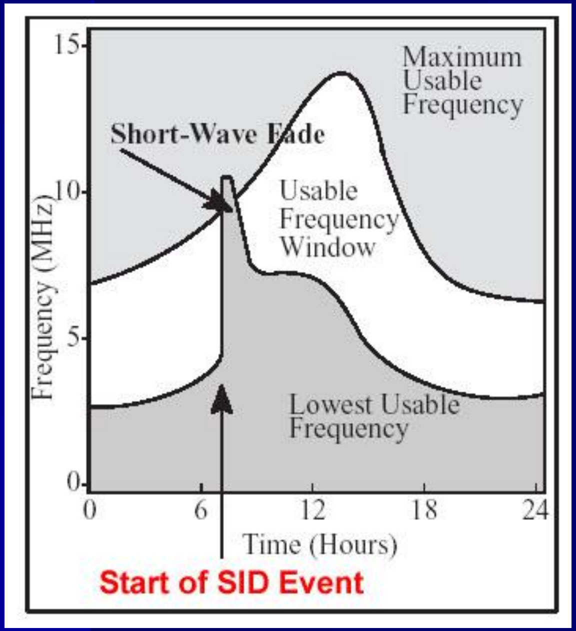
Expectable Crisis of Radio Wave Communication

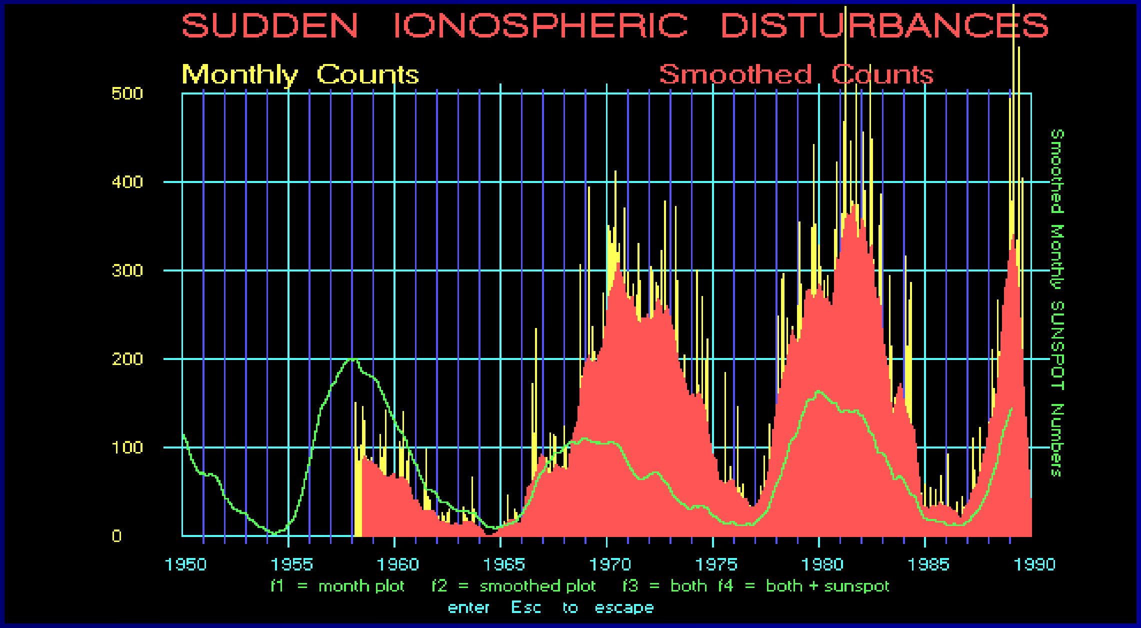


Expectable Crisis of Radio Wave Communication

∆ Sudden Ionospheric Disturbances (SID)

A solar flare transmits UV and X-ray radiation that rapidly reaches the Earth (this is take about 8.5 min). This produces abnormally high ionization in the D-region causing increased absorption of MF, HF and VHF frequencies and also increased reflection of LF and VLF. It can cause a complete and sudden loss of HF propagation. This can only occur on the sunlit side of the Earth and is most frequent at the maximum of the sunspot cycle.

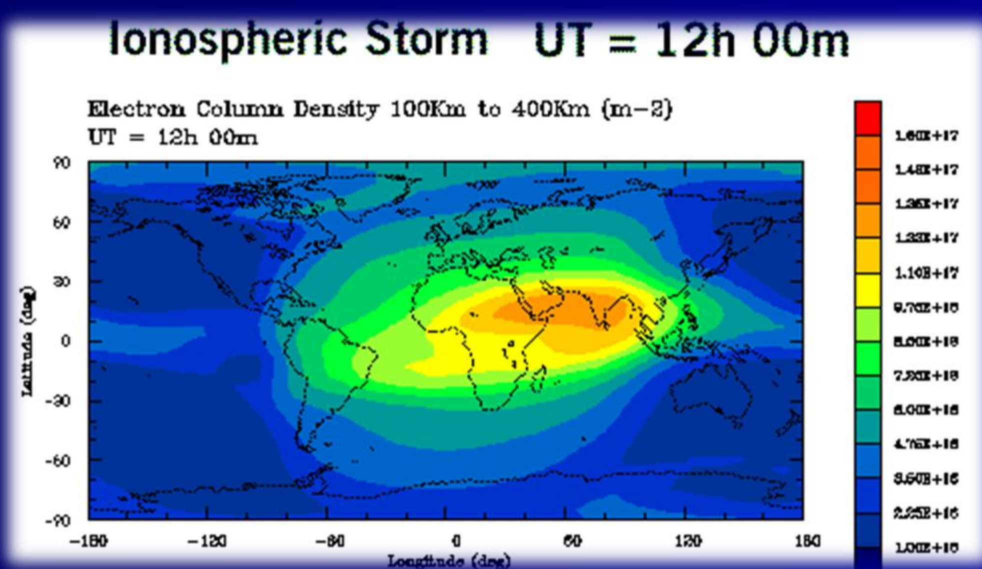




Expectable Crisis of Radio Wave Communication

∆ Ionospheric Storms

These may last for several days and are caused by terms of charged particles (protons and electrons). They may take one or two days to reach the Earth and are deflected by the Earth's magnetic field towards the **auroral zones**. The cause increased ionization in the D-region and an expansion and diffusion of the F_2-layer, causing decreased critical frequencies and higher heights. Again ionospheric storms are most severe at solar maximum but are, perhaps, more significant at solar minimum.



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∆ Polar Cap Absorption (CPA)

There are infrequent but major disturbances that occur throughout the polar regions. They are caused by high energy protons that are guided by the earth's magnetic field towards the polar regions. These may take from 15 minutes to 3 hours to reach the Earth from the Sun. These are called polar cap absorption events or solar proton events (SPE). They cause a considerable increase in D-layer ionization resulting in strong HF and VHF absorption, blacking out HF communication in the polar regions for up to a day. The SPE itself may last for up to a week or more. They are almost always preceded by a major flare and occur most often at a sunspot maxima.

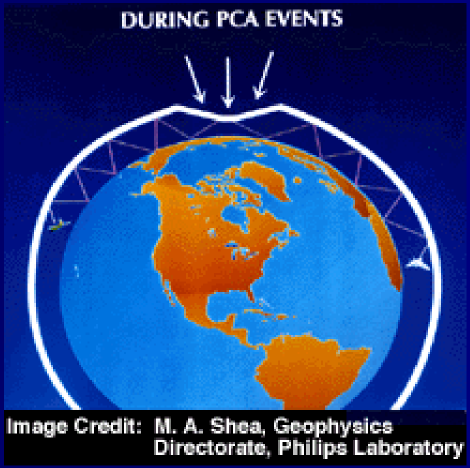
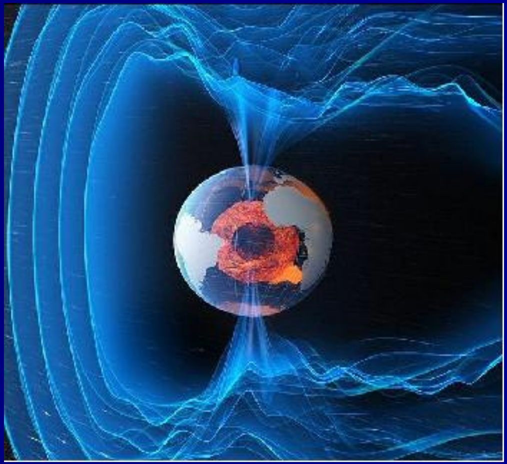


Image Credit: M. A. Shea, Geophysics Directorate, Philips Laboratory



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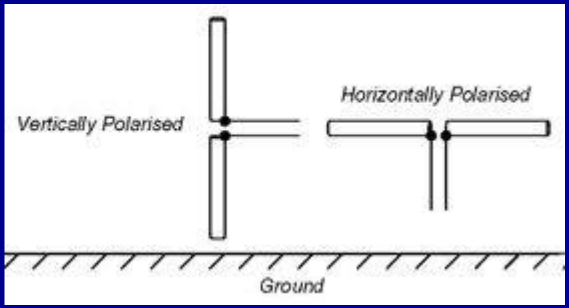
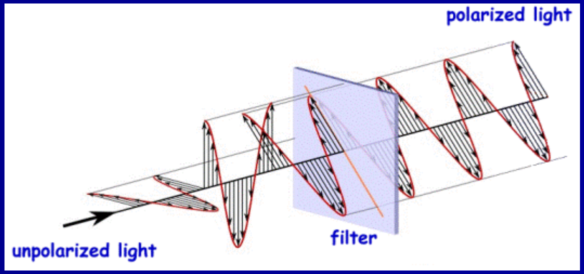
Δ Polarization

When a radio wave travels through the ionosphere its Electric Field impacts an oscillatory motion on the electrons. These re-radiate modifying the velocity of the radio wave and if the electron concentration is changing, refracting the **wave back towards the Earth**, if its frequency is not too high. The Earth's magnetic field modifies the oscillatory motion of the electrons causing them to move in complicated orbits.

Their re-radiation is not, generally, in the same polarization. The polarization changes continuously as the wave travels through the ionosphere. It becomes split into two components; the **ordinary wave** and the **extraordinary wave**. The o-wave behaves practically the same as if the magnetic field was not present. This effect is most apparent for waves that have traveled in the upper F-region. The layer appears to split as the o-wave and x-wave propagate with slightly different delays.





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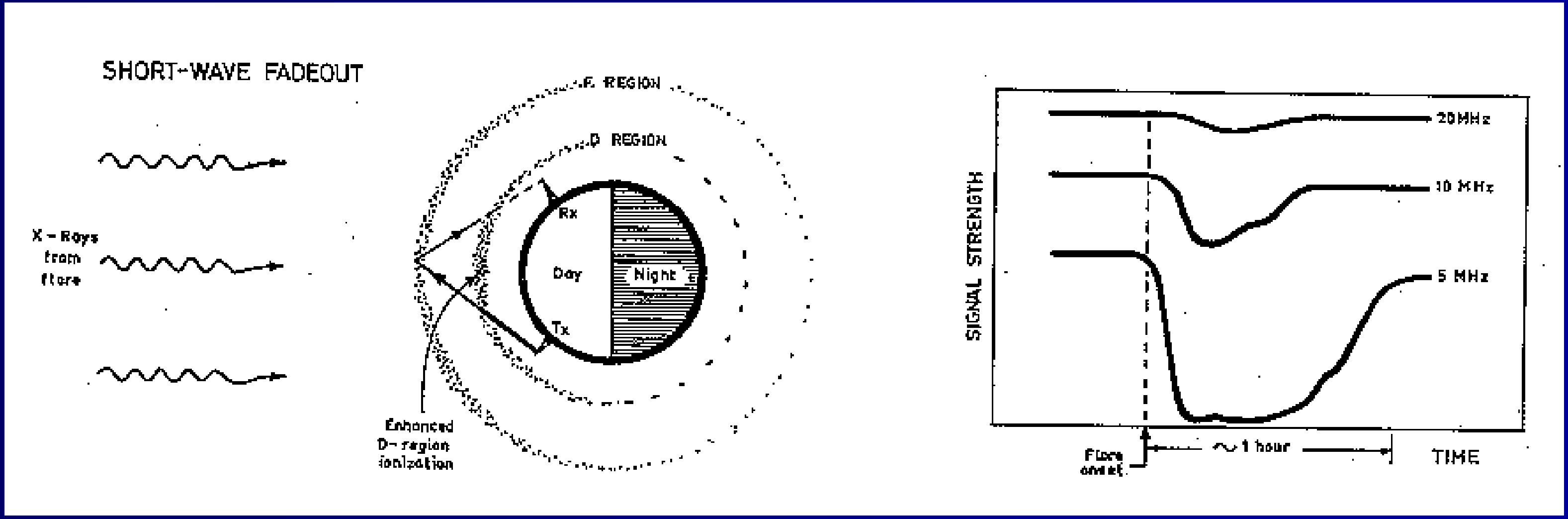
∆ Short Wave Fadeout (SWF)

During a solar flare, absorption of short wave by the D-region starts to arise strongly. As a result of it, Short Wave transmission can be completely terminated. This is known as the "**SW fadeout**". Mainly the lower frequencies in the SW band are heavily affected.

Reflection of SW during a SWF is expected to be completely vanished. But under any circumstance, ground waves are not being interrupted and received as usually by the receiver. This is called as the "Short wave Backout"



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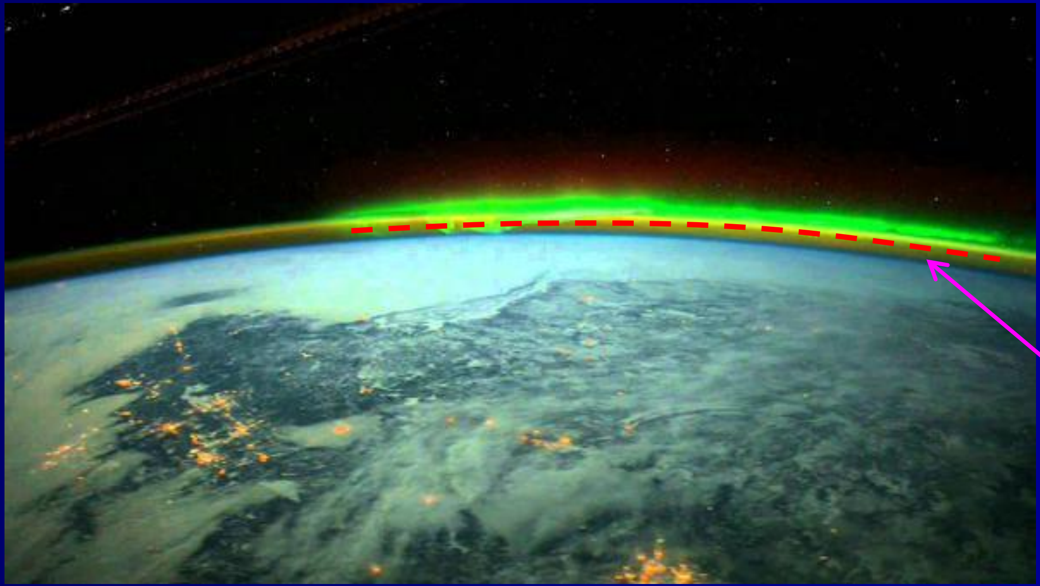
∆ Sudden Enhancement of Atmosphere

Molecular density (ions and electrons) of the D-region is tends to be high during a solar flare. Thus, the lower frequency waves starts to reflect. Randomly this D-region can be expanded as well. In such situations, one can be recognize a lower layer of the D-region. This layer is known as the **Echo Surface**. An increasing trend of SW can seen as a result of the formation of this Echo Surface. This phenomena is known as Sudden Enhancement of Atmosphere.



Echo Surface

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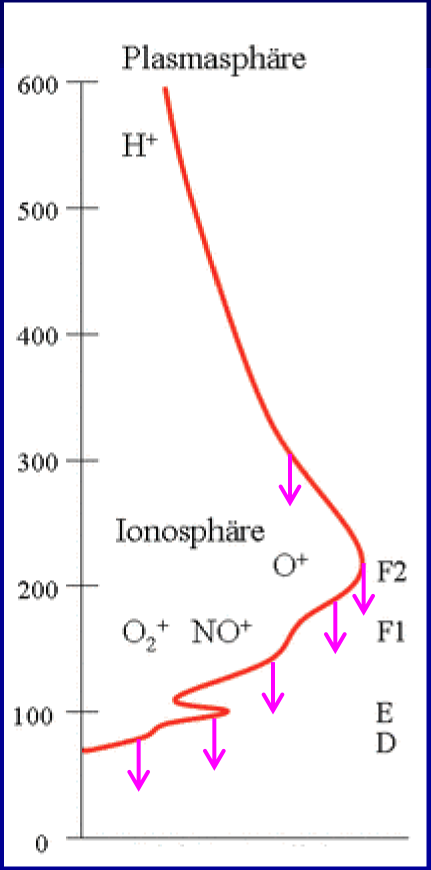
Δ Doppler Shift of the Ionospheric Layers



When a solar flare has occurred, highs of the ionospherics D, E and F are starts to decrease. OR one can say, they move downwards. This movement is called the Doppler Shift of the Ionospheric Layers. Associated with this event, a shift in frequencies at hertz level can also be observed. This is known as the "Sudden Frequency Deviation" (**SFD**)

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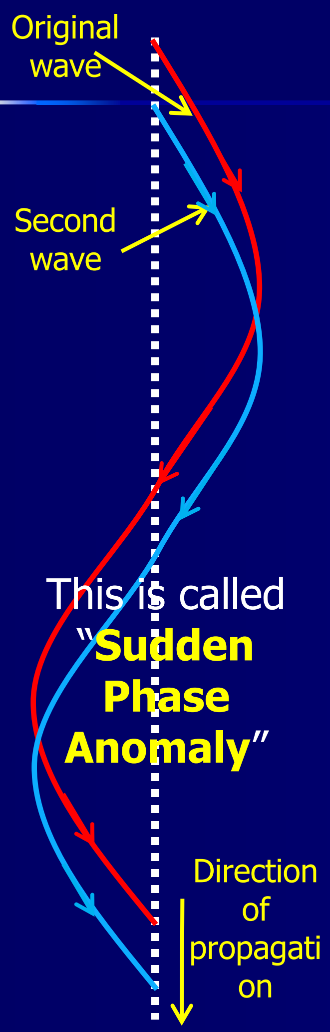
∆ Doppler Shift of the Ionospheric Layers



Thus the phase of the wave is supposed to be shifted, if a higher wave length is being used. This is effected only the low frequencies (higher wave lengths)

If a radio wave being send **towards the Earth surface from a satellite, ionosphere absorb the higher frequencies specially during a solar flares**. As a result of it, **noises associate with such waves are absorbed by the ionosphere, which is an advantage for the radio communication**.

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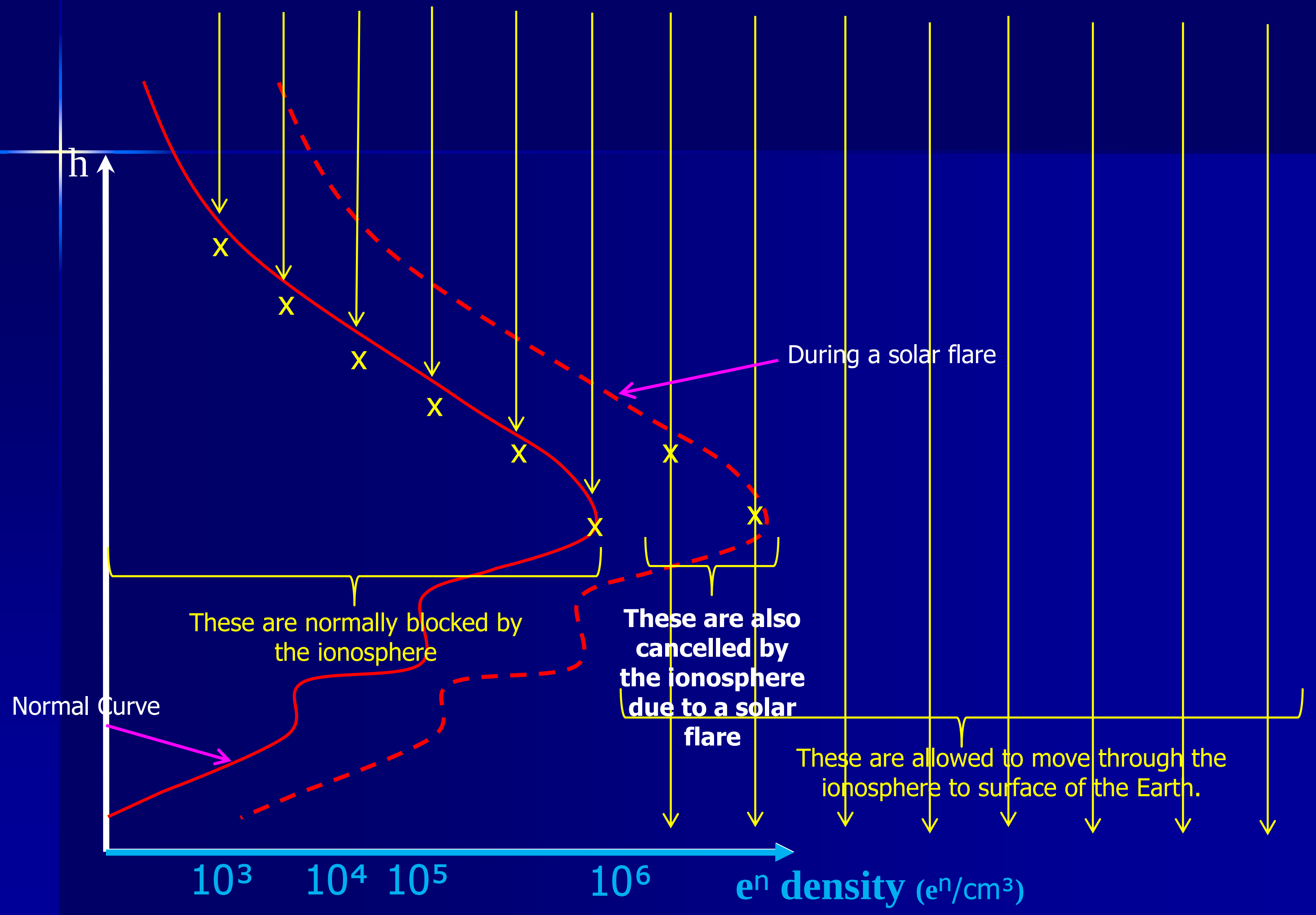
Δ Sudden Cosmic Noise Absorption

Noises added by the atmosphere for the SW high frequency radio waves, during a solar flare are absorbed by the peaks of the atmosphere. This is known as the **sudden cosmic noise absorption**.

In generally, we send high frequency short waves from the top side of the ionosphere towards the surface of the Earth, such waves are suppose to exhibit following properties,

1. wave should be strong enough,
2. it should focused towards the corresponding receiver.

Noises added by the atmosphere for the SW high frequency radio waves; absorbed by the peaks of the atmosphere! (**Noises are high frequencies**)



Expectable Crisis of Radio Wave Communication

∆ Sudden Cosmic Noise Absorption

In generally, we send high frequency short waves from the top side of the ionosphere towards the surface of the Earth, such waves are suppose to exhibit following properties,

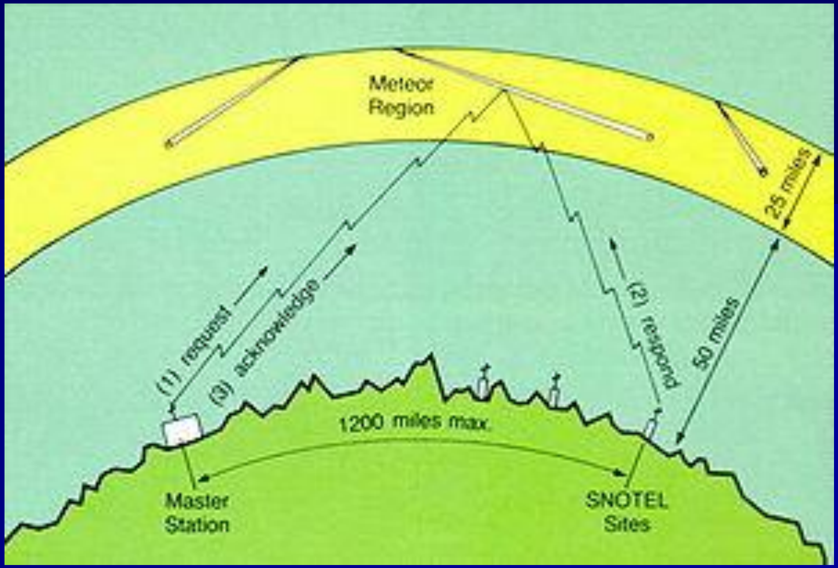
1. wave should be strong enough,
2. it should focused towards the corresponding receiver.

Basically **two main advantages** can be observed with **such focusing antennas**.

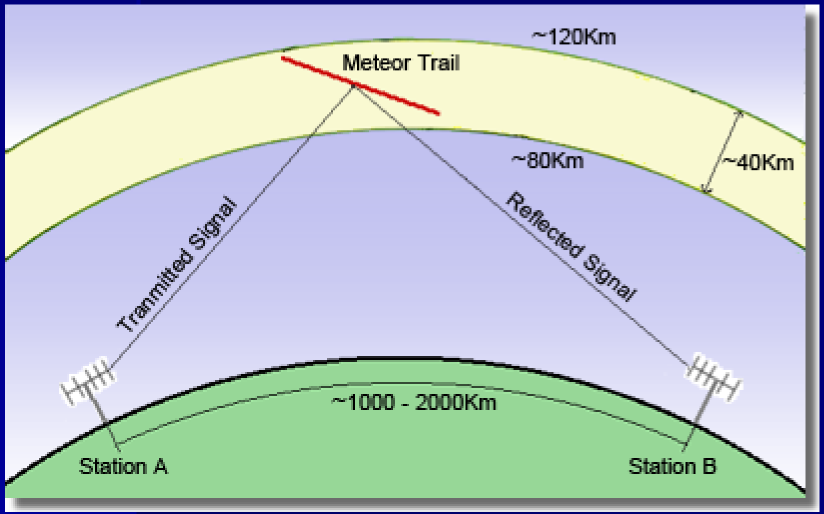
- Due to the gain of the antenna, station can receive signals with extra strength.
- The chances of affecting the signal by the background noise is essentially small as the signal is focused in to a narrow direction.

Expectable Crisis of Radio Wave Communication

- **Meteor Scattering**



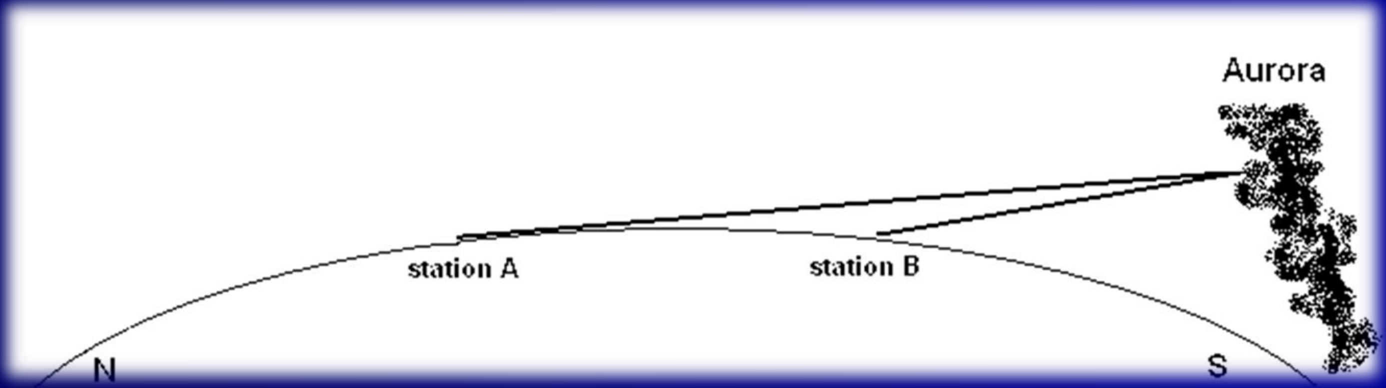
Meteor scattering relies on reflecting radio waves off the intensely ionized columns of air generated by meteors. While this mode is very short duration, often only from a fraction of second to couple of seconds per event, digital meteor burst communications remote stations to communicate to a station that may be hundreds of miles up to over thousands of miles away, without the expense required for a satellite link. This mode is most generally useful on **VHF** frequencies between 30 MHz and 250 MHz.



Expectable Crisis of Radio Wave Communication

- **Auroral Reflection**

Intense columns of Auroral ionization at 100 km altitudes within the auroral oval reflect radio waves, perhaps most notably on HF and VHF. The reflection is angle sensitive-incident ray vs. magnetic field line of the column must be very close to right-angle. Random motion of electrons spiraling around the field lines create a Doppler-spread that broadens the spectra of the emission to more or less noise-like-depending on how high radio frequency is used. The radio-auroras are observed mostly at high latitudes and rarely extend down to middle latitudes.



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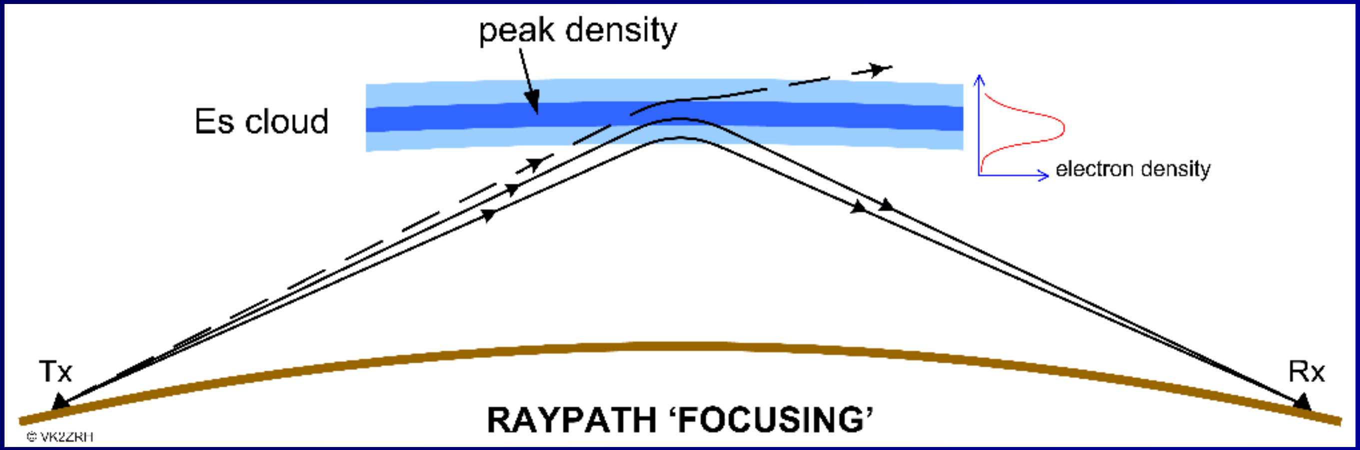
Sporadic – E (E_s) Propagation

Sporadic – E Propagation can be observed on **HF** and **VHF** bands. It must not be confused with **ordinary HF** with **E-layer** propagation. Sporadic – E at mid latitudes occurs mostly during summer season, from May to August in the northern hemisphere and from November to February in the southern hemisphere. There is no signal cause for this **mysterious propagation mode**. The reflection takes place in a thin sheet of ionization around 90 km height. The ionization patches drift westwards at a speed of few thousand kilo meters per hour.



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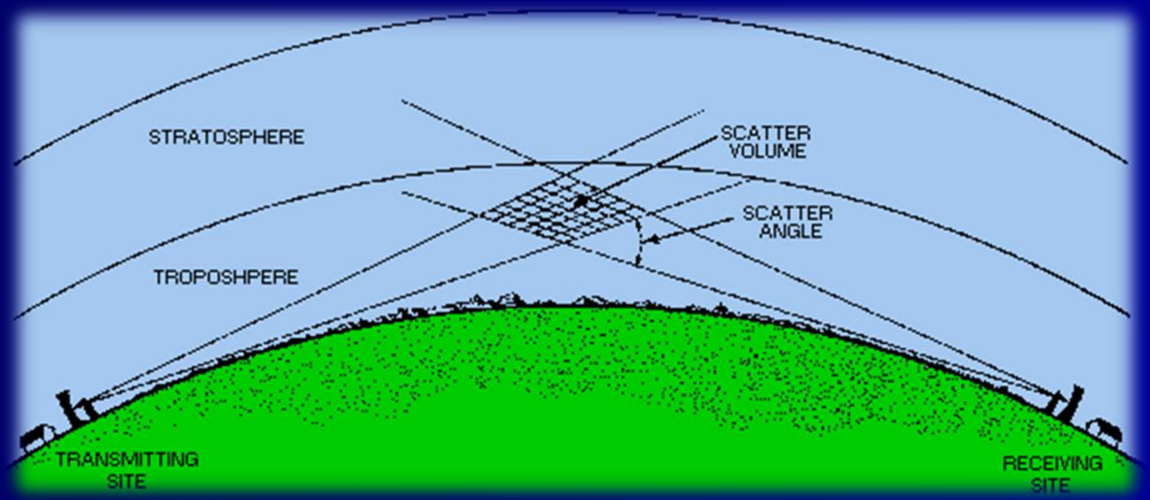
- **Tropospheric Scattering**

At VHF and higher frequencies, small variations (turbulence) in the density of the atmosphere at a height of around **10 km** can scatter some of the normally line-of-sight beam of radio frequency energy back toward the ground, allowing over-the-horizon communication between stations as far as 800 km apart. The military developed the White Alice Communication System covering all of Alaska, using this Tropospheric Scattering principle.



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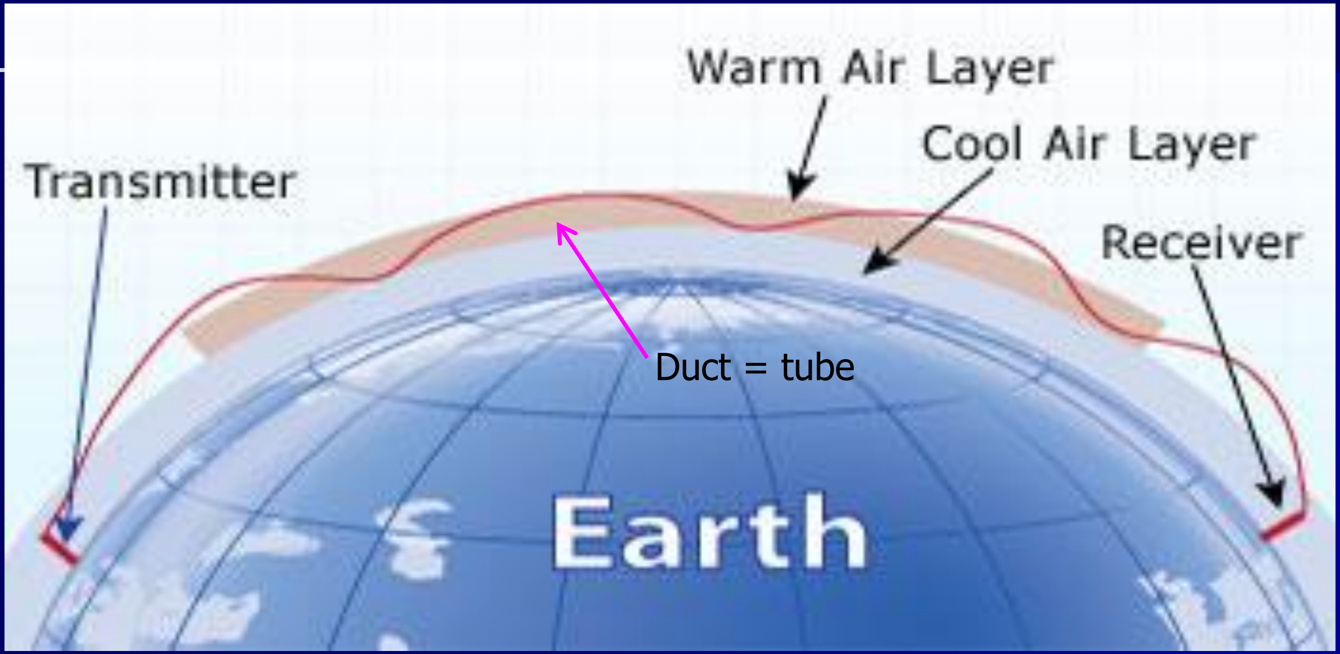
- **Tropospheric Ducting**



Sudden changes in the atmosphere's vertical **moisture content** and temperature profiles can on random occasions make microwave and **UHF** & **VHF** signals propagate hundreds of kilometers up to about two thousands of kilometers and for ducting mode even far their-beyond the normal radio horizon.

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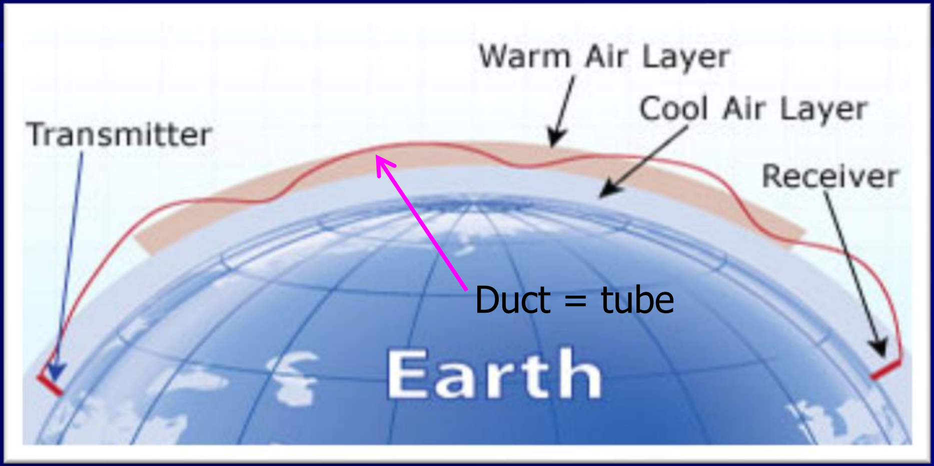
- **Tropospheric Ducting**



The inversion layer is mostly observed over high pressure regions, but there are several tropospheric weather conditions which create these randomly occurring propagation modes. Inversion layer's altitude for non-ducting is typically found between 100 m to about 1 km and for ducting about 500 m to 3 km, and the duration of the events are typically from several hours up to several days. Higher frequencies experience the most dramatic increase of signal strengths, while on low-VHF and HF the effect is negligible. Propagation path attenuation may be below free-space loss.

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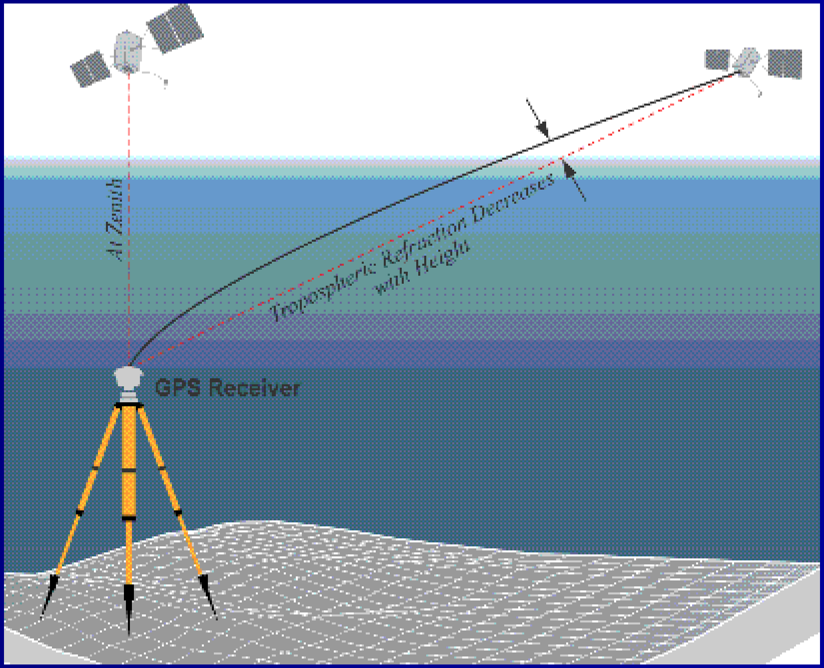
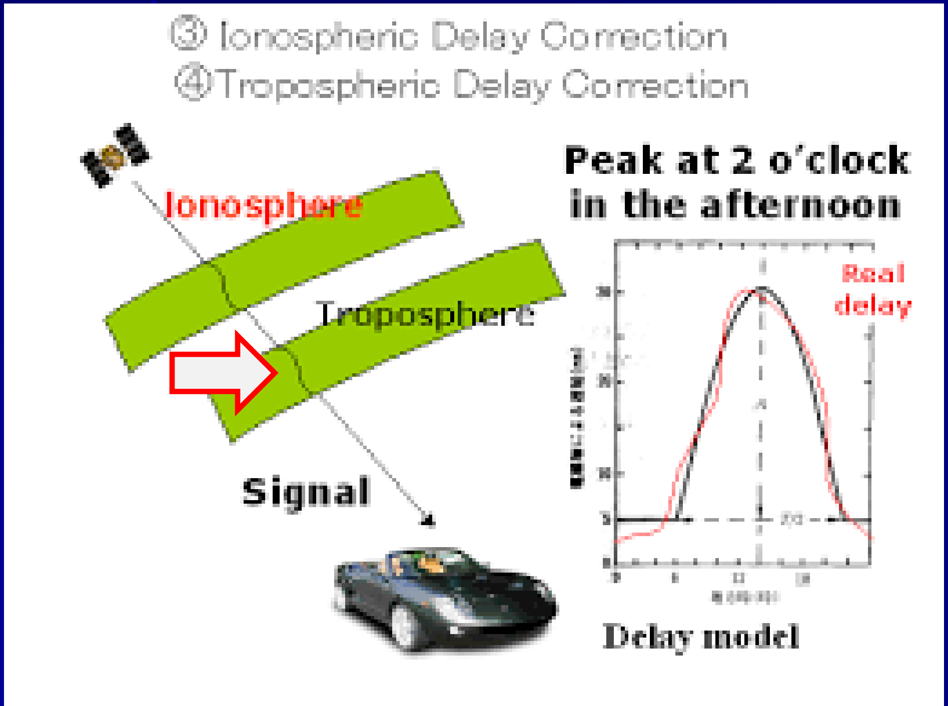
- **Tropospheric Delay**

This is a **source of error in radio ranging techniques**, such as the **Global Positioning System** (**GPS**)





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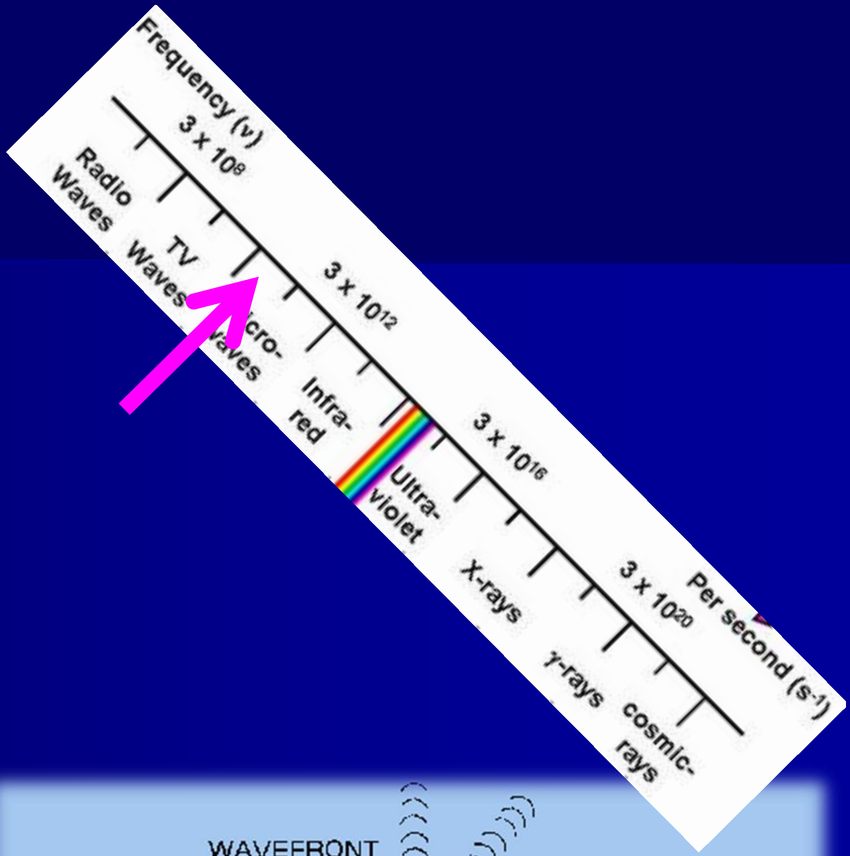
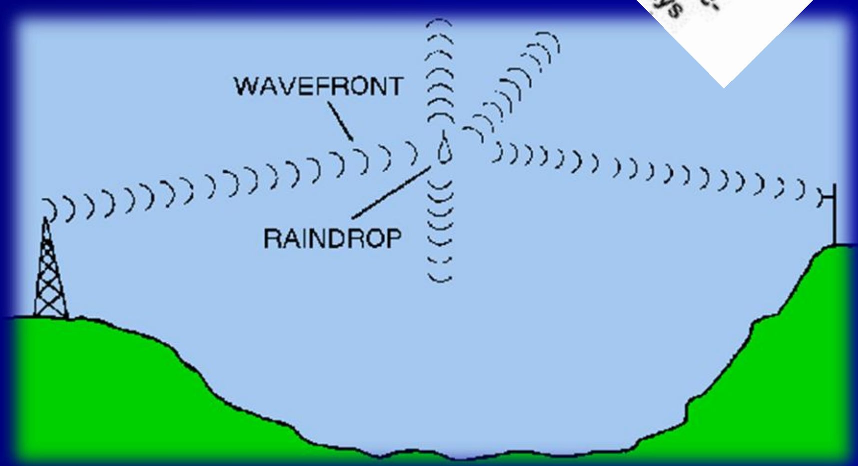
- **Rain Scattering**

Rain Scattering is purely a microwave propagation mode and is best observed around 10 GHz, but extends down to a few gigahertz, the limit being the size of the scattering particle size vs. wavelength. This mode scatters signals mostly forwards and backwards when using horizontal polarization and side-scattering with vertical polarization. Forward-scattering typically yields (outputs) propagation range of 800 km. Scattering from snow flakes (chips) and ice pellets (pills) also occurs, but scattering from ice without watery surface is less effective.





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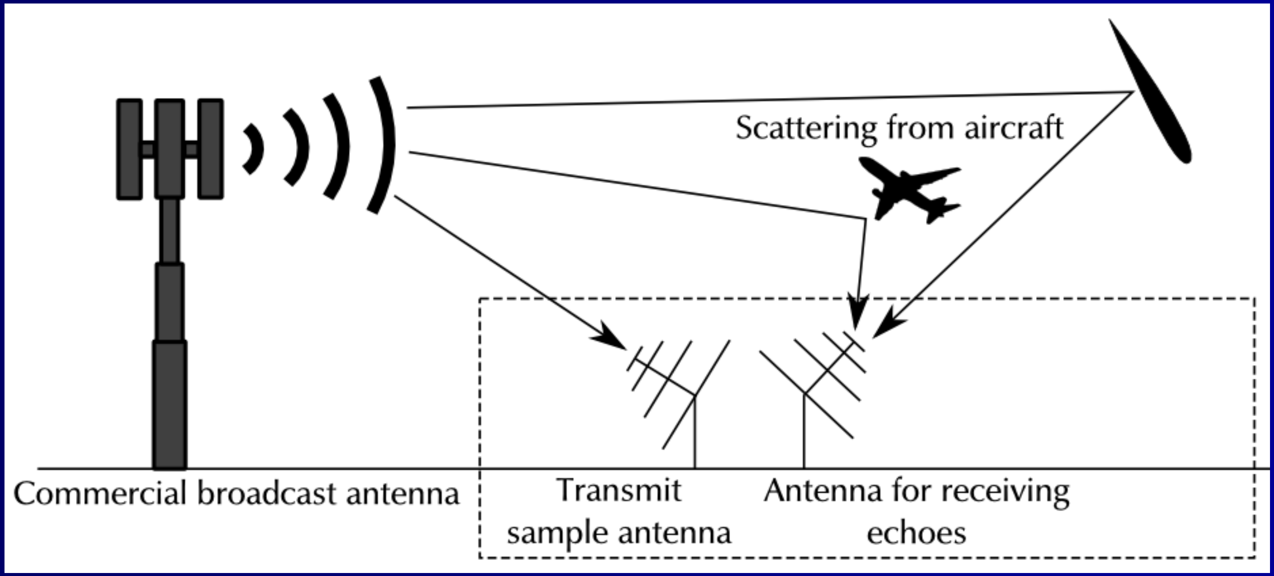
- **Aero plane Scattering**

Aero-plane Scattering (or most often reflection) is observed on VHF through microwave and besides (also) back-scattering, yields momentary propagation up to **500 km** even in a mountain-type terrain (land space). The most common back-scatter application is **air-traffic radar** and **biostatic forward-scatter guided-missile** and **aero-plane detecting trip-wire radar** and the **US space radar**.



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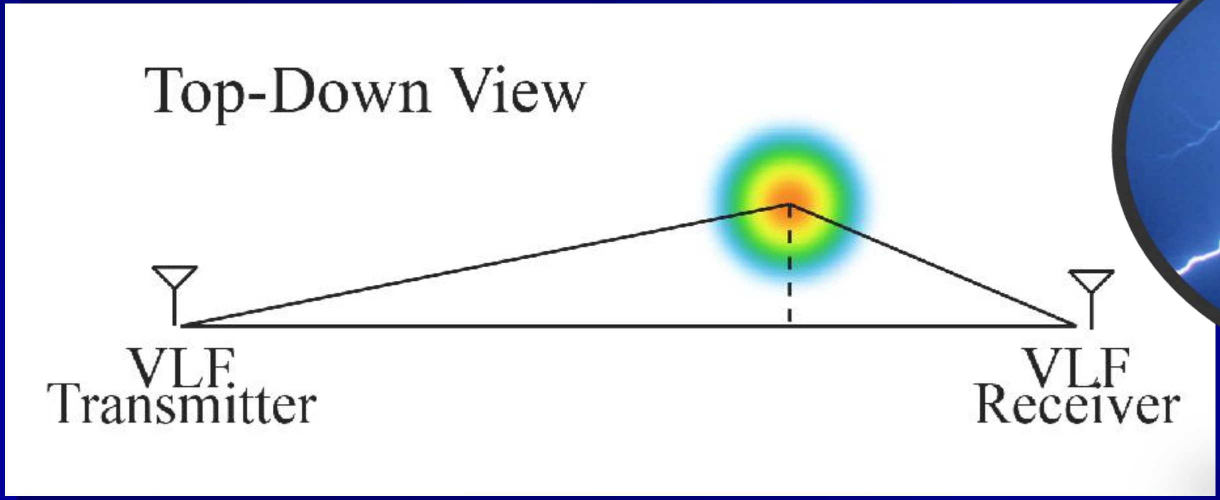
- **Lightning Scattering**

Lightning Scattering has sometimes been observed on VHF and UHF over distance of about 500 km. **The hot lightning channel scatters radio waves for a fraction of a second**. The **RF** noise burst (explosion) from the lightning makes the initial part of the open channel unusable and the ionization disappears soon because if combination at low altitude high atmospheric pressure. Although the hot lightning channel is briefly observable with microwave radar, **this mode has no practical use for communication**.



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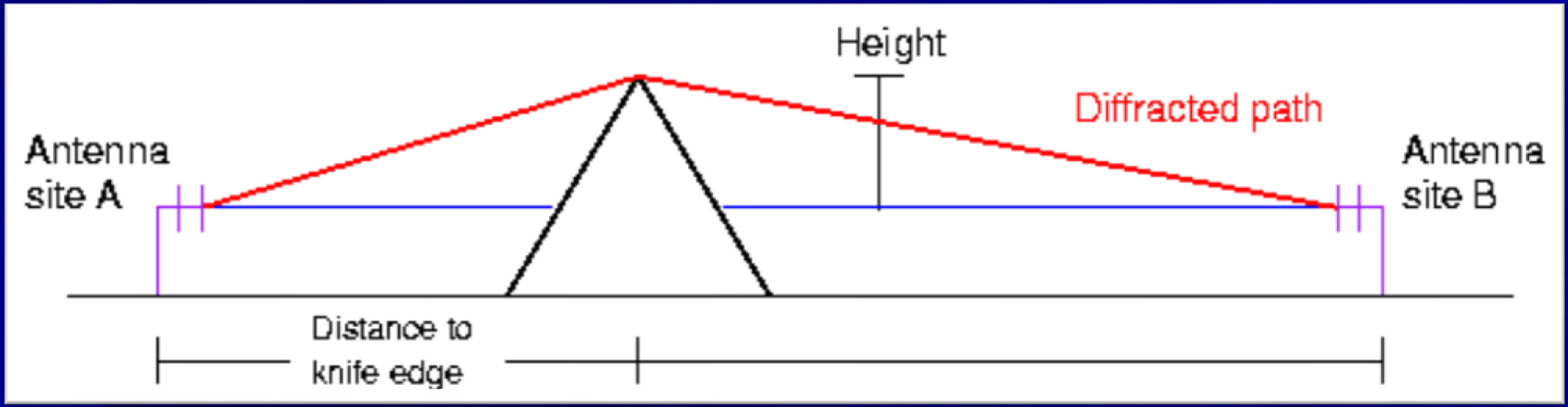
- Knife-Edge Diffraction

The Knife-Edge Diffraction is the propagation mode where radio waves are bent around sharp edges. For example, this mode is used to send radio signals over a mountain range when a line-of-signal path is not available. However, the angle can not be too sharp or the signal will not diffract. The **diffraction mode requires increased signal strength**, so higher power or better antennas will be needed than for an equivalent line-of-signal path.



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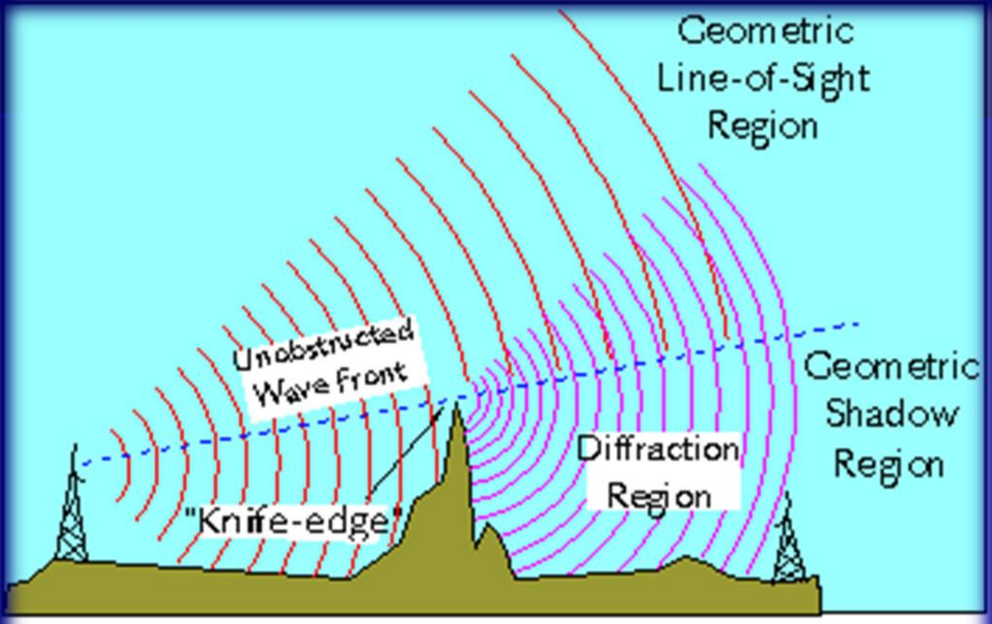
- **Knife-Edge Diffraction**

Diffraction depends on the relationship between the wavelength and the size of the obstacle. Lower frequencies diffract around large smooth obstacles such as hills more easily. Diffraction phenomena by small obstacles are also important at high frequencies.



knife-edge effect

Signals for urban cellular telephony tend to be dominated by ground-plane effects as they travel over the rooftops of the urban environment. They then diffract over roof edges into the street, where multi-path propagation, absorption and diffraction phenomena dominate.

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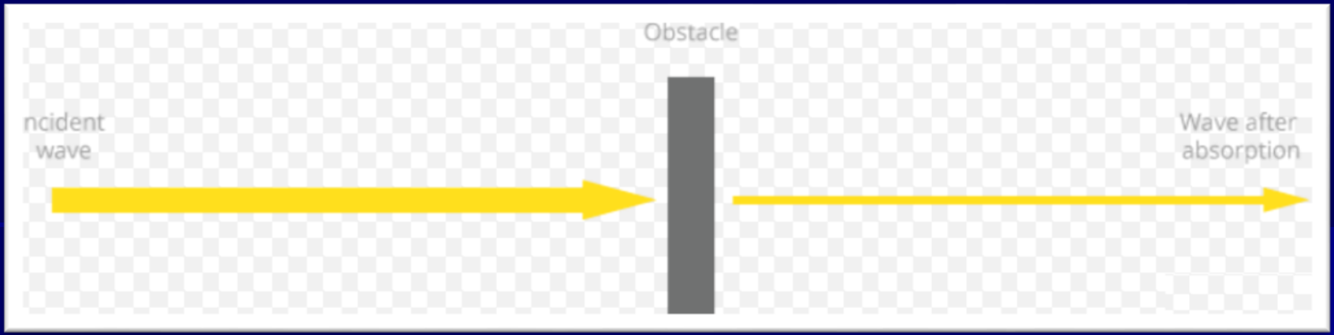
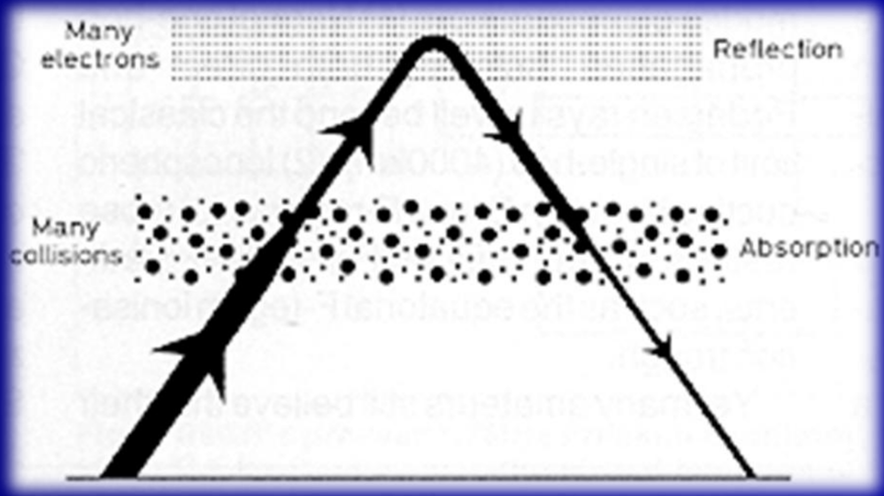
Absorption



Low frequency radio waves travel easily through brick and stone and **VLF even penetrates sea-water**. As the frequency rises, absorption effects become more important. At micro-wave or higher frequencies , absorption by molecular resonance in the atmosphere (mostly water/water-vapor, and oxygen) is a major factor in radio propagation.

For example, in the 58 – 60 GHz band there is a **major absorption peak** which makes **this band useless for long distance use**. This phenomenon was first discovered during radar research in world war II.



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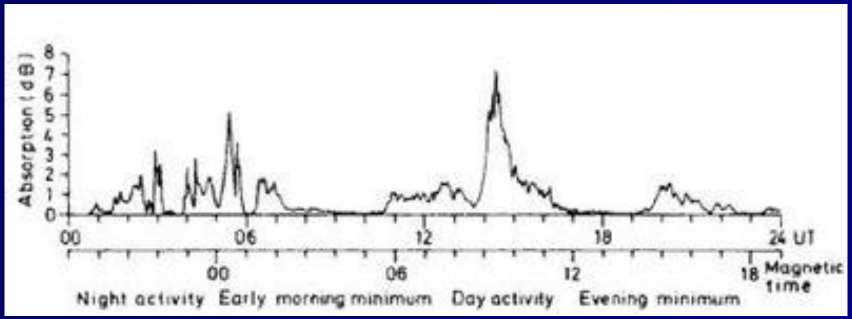
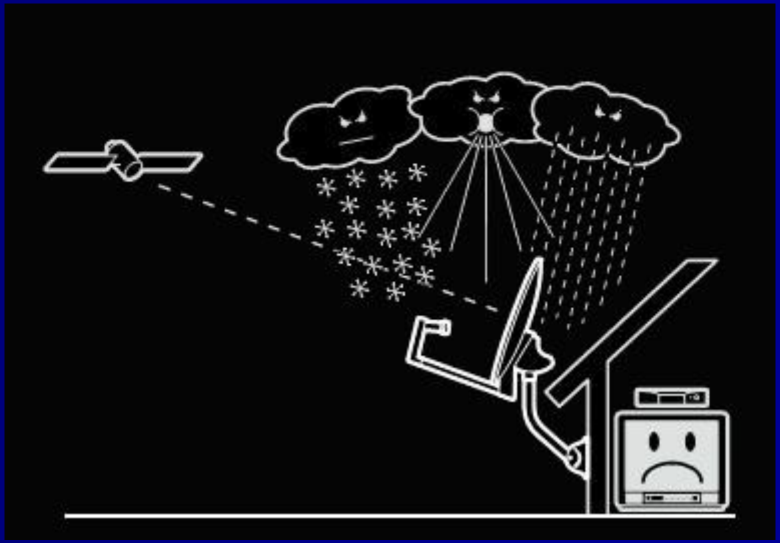
Absorption

Beyond around 400 GHz, the Earth's atmosphere blocks some segments of spectra while still passes some this is true up to UV light, which is blocked by ozone, but Visible Light and some of near infrared is transmitted.



Heavy rain and snow also affect microwave reception.




Thank You !