Commo Brief: Propagation & The Weather

www.gawg.cap.gov/commo

Weather And Propagation

Wind, temperature, and water can combine in many different ways in our atmosphere. Rain, ice crystals in clouds, snow, hail, and other forms of precipitation can cause radio signals to scatter or be absorbed. Temperature inversions, which are caused by warm air masses rising above colder surface air masses, can cause signals to travel much farther than they normally would.

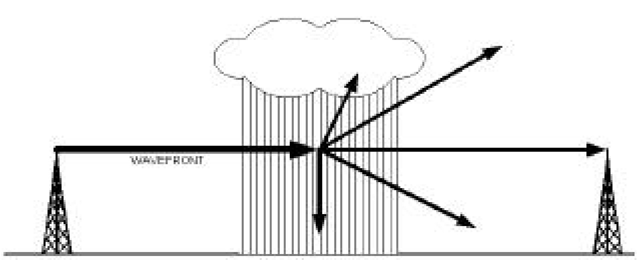
There are no solid rules concerning weather and propagation, but over the years communicators have noticed and have taken advantage of conditions when they have become available to extend communications distances.

Precipitation and Attenuation

Water or water vapor is always in our atmosphere in one form or another. Attenuation due to precipitation is largely dependent on the frequency. Higher frequencies, such as microwaves, are more susceptible to attenuation from water in the atmosphere than lower frequencies, such as VHF or HF. In HF, the effect of attenuation due to water in the atmosphere is largely ignored in calculations.

Rain

Attenuation due to raindrops is greater than other types of precipitation. The raindrop acts as a poor dielectric, which absorbs power from the wave and dissipates the power by heat loss or by scattering. Scattering is more pronounced at frequencies above 100 MHz, and is significant at frequencies above 6 GHz.



ATTENUATION DUE TO RAIN SCATTERING

Fog

Since fog is comprised of water droplets suspended in the air, it could be considered another form of rain when considering its attenuation characteristics. Factors such as the quantity of water per unit volume (density) and the size of the droplets determine the level of attenuation that will be experienced. Attenuation due to fog is minor, and is generally ignored at frequencies below 2 GHz.

Snow

The attenuation effect of snow is not generally well understood, but is believed to be less than that of rain. Rain is as much as eight times denser than snow, and as a result, rain falling at the rate of 1 inch per hour, for example, would represent more water per cubic inch than snow falling at the same rate.

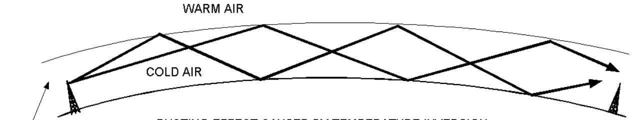
Hail

Attenuation by hail is largely dependent on the size, density, and rate of fall of the stones. Attenuation due to hailstones is considered to be less than that for rain.

Temperature Inversion

Under normal atmospheric conditions, the warmest air is found near the surface of the Earth. As altitude increases, the air becomes cooler, resulting in a layer of warm air covered with cool air. Occasionally a cool air mass may be overtaken by a warm air mass, which rises and covers, or "traps" the cooler air under it. This phenomenon is called a temperature inversion, and would appear as a single layer or a series of layers if the layers could be seen.

These layers act as ducts or channels that will propagate radio waves along the ducts for extended distances, and the process is known as "ducting." For ducting to occur, the transmitting antenna must extend into the duct, or the angle of incidence must be low enough for the boundary between the layers to refract the wave back into the duct. A wave with a high angle of incidence, such as one perpendicular to, or nearly perpendicular to the boundary layer, would not be refracted and would be lost to space.



DUCTING EFFECT CAUSED BY TEMPERATURE INVERSION

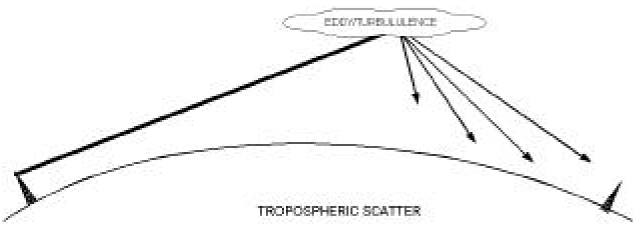
Before the advent of satellite and cable television, the strong reception of far-away television stations was an indicator of an opening due to ducting. Ducting may result in multiple hops of a signal as it travels between the boundary layer or various layers of a duct.

Tropospheric Propagation

The troposphere is the lowest portion of the Earths atmosphere, and contains virtually all the planet's weather. It extends to about 11 km (7 miles), and is in constant motion. This motion results in turbulence, or eddies, which are often experienced during aircraft flight. These eddies have refractive qualities that permit the scatter of signals of smaller wavelengths, generally above 100 MHz.

When these signals encounter an eddy, they are subject to an abrupt change in velocity, causing a small amount of energy to scattered in a forward direction and returned to the Earth at distances beyond the horizon. This may be repeated as the wave encounters other eddies. This enables VHF and UHF signals to be transmitted well beyond the normal line-of-sight distances.

Tropospheric scatter, unlike a normal sky wave which is quickly attenuated as it is diffracted beyond a horizon, provides a usable signal well beyond a horizon. Tropospheric scatter can be visualized as a relay point that can "see" beyond the horizon.



The tropospheric area midpoint between the transmitting and receiving stations contributes most to tropospheric scatter, and is generally just above the radio horizon of each station. Daily and seasonal changes occur in the atmosphere, causing a variation in signal strength called long-term fading. Since turbulent conditions are constantly changing in the atmosphere, rapid fading also occurs as path lengths and individual signal levels change. No complete fade-out occurs because the average signal level remains stable.

Signals received by tropo scatter are relatively weak, as little of the original signal is actually received. Good antennas, sensitive receivers, and powerful signals are required for consistent and reliable communications.