Rain Scatter, SHF and EHF

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In 1999 I presented a paper and talk at Microwave Update on Rain Scatter. When asked about a topic for 2019 conferences, I decided I could probably dust off a twenty year old paper, update it if needed and present it again. After all, many folk didn't pay attention the first time, may have forgotten it, and many would have not attended that conference 20 years ago. Because the EHF bands had changed in the intervening years, at least I had to execute some simulations to update the bands. That led me to discover that the original data were based on incorrect assumptions, and that all the polar plots I had presented two decades ago were wrong. So, it was time to update all of those data. Fortunately, all of the basics were right, along with a few of the diagrams.

When we look up on a clear day we see a blue sky with white clouds. At sunset we might enjoy hues from red through yellow. We can take pictures through a polarizing filter to darken the sky to a rich deep blue. Look down at a soap bubble or a film of oil in a puddle where pretty colors appear to swim around. We make over-the-horizon contacts on ham bands all the time (see Figure 1). What do all these events have in common? Scattering.

Figure 1. Over-the-horizon contacts made by radio amateurs usually involve scattering.

The word "scattering" we can mean a variety of things – but generally scattering means that things go in a variety of directions - landing in different places often not in the direction thrown. We say "scattered to the four winds", or "the population from that country is scattered across the globe", or "Tom is scatter-brained". This general sense of scattering is where the specific term that we use comes from because electromagnetic waves, when scattered by their interactions with matter, go in new directions, arriving in different places than they were originally directed.

1 What is RF scattering?

The scattering of electromagnetic energy by matter is a complex subject, but there are a few relatively easy to understand principles that account for it. Fundamentally, the interaction between any EM wave and any matter is an example of scattering. This includes reflection and refraction. Because volumes have been written on the subject, and volumes more are yet to be written and understood (and because I am not really an expert), I can only cover very basic field-matter interaction and scattering in this report. Some simplifications are made here in order to understand the interactions pertinent to scattering in amateur radio communications. I will focus on rain as a scattering medium.

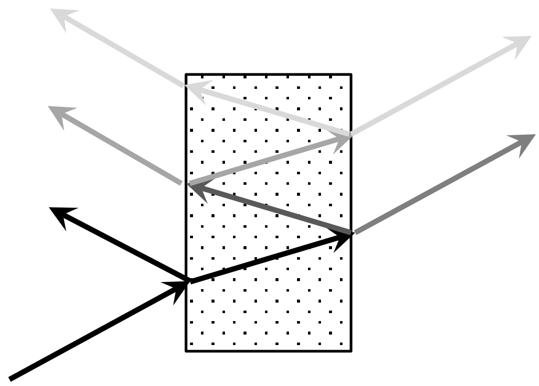

Figure 2. A dielectric slab teaches some of the principles of general EM scattering.

Early attempts to understand scattering were unable to explain some observations. Those understandings were originally based on interactions with slabs of matter. For example, think of light hitting a clear glass plate, which reflects some waves off the backside (where the wave impinges on the object in this simplified diagram Figure 2). Some of the energy continues through the object, and the energy is again split back into the object (the glass) and some of the energy comes out the other side. Internal reflections continue with some "leaking out" on every bounce. In our example the glass has no absorption, but if it did, some of the internal energy would be converted to heat, so that the emissions total less than the energy entering. Although this explanation accounts for interactions with large slabs, it did not account for the scattering of light in many directions by particles. Also, the polarization that is exhibited by a group of particles is very different from what a slab-based explanation predicted. This and other problems led early researchers to concentrate efforts in unraveling the nature of wave/particle interaction, and that has led to a more thorough understanding of scattering.

A good way to think of scattering by material is to consider that the EM wave does at least three things. The first, like with a slab, is reflection. The interaction at the border between the transmitting medium (air) and the material (a dielectric like water or glass) is easily determined by the polarization of the wave and the difference between the dielectric properties of the medium and the particle. Ignoring polarization effects, the reflection angle is the same as the incoming angle, and the power is split between the reflection and that which enters into the particle. The second thing a wave does, again like with a slab, is refraction. The wave propagates inside the particle at some angle, again determined by the entry angle, the relative dielectric properties and the polarization. When it hits the opposite side of the material it again is divided into a part that reflects back into the material and another that emerges and continues to propagate in the medium. The third thing is internal excitation (see Figure 3) and in general is different from what happens with a slab. When the material is large and flat relative to a wavelength (like a slab), this interaction can be modeled as repeated reflections, but when the material is near to or smaller than a wavelength and more compact than a slab, it is called a particle. The internal energy excites the particle like a resonator, which emits like an antenna. When the particle is small relative to a wavelength it acts similar to a Hertzian Dipole.

Regarding particles, the two most important factors controlling the excitation-based interactions are the dielectric differences (between the medium and the particle) and the size of the particle (in comparison to the wavelength of the EM field). Also, there are polarization sensitivities in the scattering process.

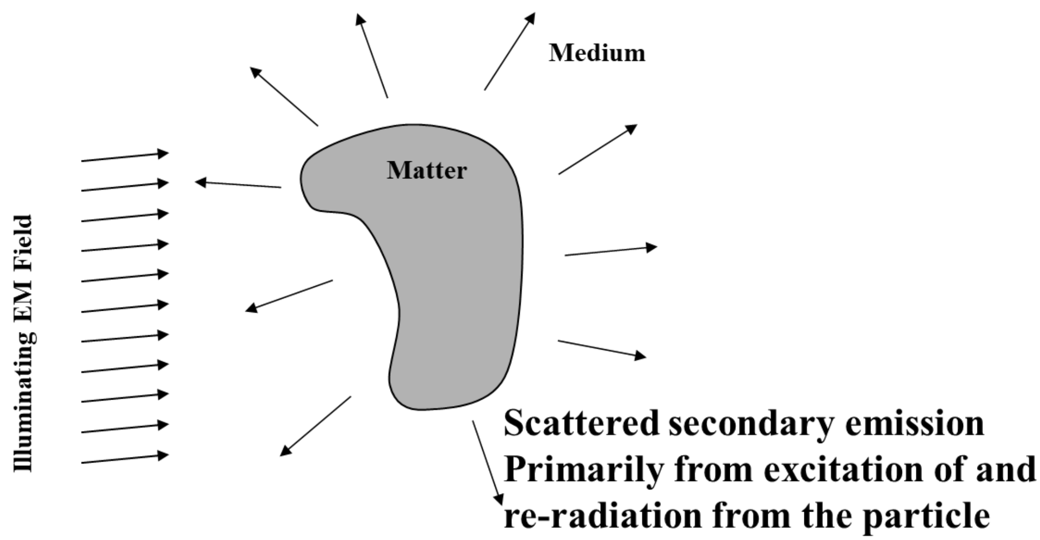

Figure 3. Particles re-radiate energy that enters them

Scattering in any volume is caused by heterogeneity– the "mix" of it. If the EM field encounters a perfectly homogenous medium throughout its path between transmitter and receiver, then there is no scattering. The scale of heterogeneity can vary widely – consider individual atoms being different from the vacuum in which they live, or rain in air, or turbulence on a scale of several meters making invisible boluses of higher and lower pressure air. Regardless of the scale of heterogeneity, the physics of scattering applies.

But, why does matter scatter EM fields? Matter is made up of electrical charges – protons and electrons. When an object encounters an EM field, these charges are set into vibration by the electric field of the EM wave. These vibrations, in turn, radiate electromagnetic waves as a type of secondary radiation, and this radiation we call the "scattered wave". Of course, some of the energy is absorbed by the object, and converted into heat.

This explanation does not work too well for extremely small and high energy particles, such as groups of free protons and electrons. The Ionosphere contains vast regions of such particles, and is quite effective at scattering HF and some VHF signals. That kind of particle scattering is even more complicated than our topic, and isn't applicable to microwave scattering in the Troposphere by rain.

2 Particle Size vs. Wavelength

One of the significant contributions to theories of scattering has been the work by Lord Rayleigh (pronounced Ray-lee), in the late 1800s. He formulated a basis for scattering from mathematical formulations and observations that show a very strong tendency for scattering to increase dramatically as the wavelength gets shorter, or as the particle gets larger. Mie (pronounced like "me") extended this work in various papers published in the early 1900s. Mie accounted for the rapid increase of scattering with particle size coming to an abrupt end as the particle circumference approaches the wavelength of the radiation. Mie established a ratio χ which is the circumference divided by the wavelength. At χ=1 and larger the particle begins to resonate, which greatly complicates the scattering process.

It is common to divide χ (scattering to wavelength ratio) into three regions – the Rayleigh Region, extending to wavelengths larger than ten times the circumference of the particle, the Mie or Resonance Region, where wavelengths are between about ten times the circumference of the particle and 1/10 of the particle circumference, and finally the Optical Region from a wavelength of about 1/10 the particle circumference and smaller.

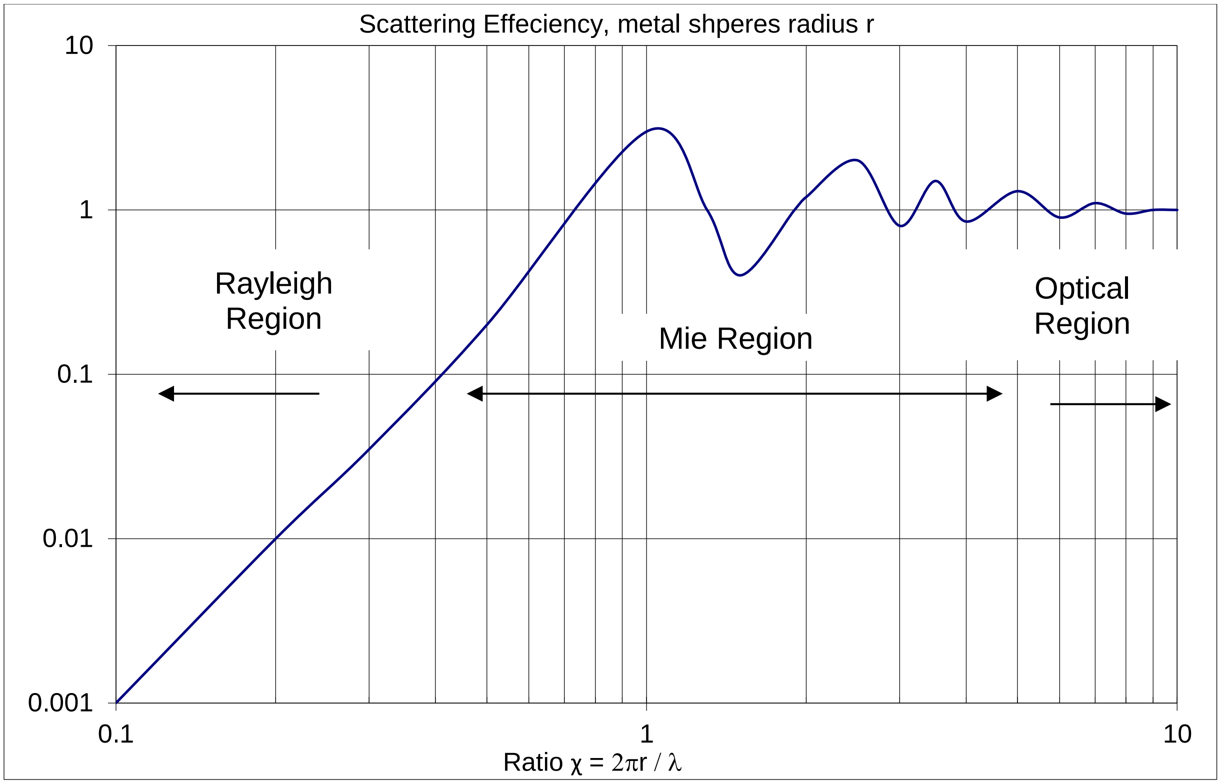

Figure 4. Scattering efficiencies vs. frequency for spheres. Various materials will reach the resonance region at slightly different ratios but the general form of this function is the same regardless of the material.

In the Rayleigh Region, the scattering efficiency increases by the fourth power of frequency. This is a pretty extreme factor, even considering our use of logarithmic scales in communications. The author and others have used rain scatter for communications on 10 GHz, 5 GHz, and 3 GHz, and have observed scattering on 2 GHz, but with very low signal levels. Using the fourth power law - at 5 GHz (about half the 10 GHz frequency) we would expect to receive 1/16 the signal (1/2 to the fourth power) - representing 12 dB less received signal level on 5 GHz than at 10GHz. At 3 GHz (1/3 of the frequency) we would expect to receive 1/81 of the signal, or about 19 dB less signal than at 10 GHz, and at 2304, less than ¼ the frequency yields 1/256 or 24 dB less signal. These figures are not exactly correct because the dielectric constant for water is changing over these frequencies, and so the scattering efficiency also is changing.

What does this mean for higher frequencies? Unfortunately this geometric increase comes to an end. As the frequency goes up (for the same particle size), we begin to enter the Mie region and the refractive index of water is decreasing. These factors combine to permit rain scattering contacts on most EHF bands under the right circumstances (and when sufficient power is available). Unfortunately, rain is often accompanied with moderate to high humidity (where the dew point approaches the air temperature). As the frequency rises in the EHF part of the spectrum, the volume where there is rain is likely to have considerable absorption due to water vapor.

3 Azimuth Dependency and Polarization

Of some concern to hams wishing to communicate via scattering, especially rain scatter is the directional dependency of the signal. In other words, does the amplitude of the scattered signal drop off at some angles, or is it enhanced at some others? Answers to this question are very difficult in some circumstances and easy in others.

For wavelength/size ratios above about 10, generally speaking, the scattering volume looks like a dipole of the same polarization as the illumination. This means that you can think of the scattering medium as “re-transmitting” the signal as a dipole would if it were centered in the scattering volume. That dipole will have the same polarization as the transmitter. This re-transmission analogy produces correct results for spherical objects (like raindrops) where there is a large wavelength/size ratio (in the Rayleigh Region).

Polarization preservation has consequences. If the transmitter is vertically polarized, then other stations could receive the signal with equal amplitude regardless of their direction relative to the scattering volume. This is the same as receiving a vertically polarized signal from a repeater with equal signal levels regardless of where one is located on a circle around the repeater site.

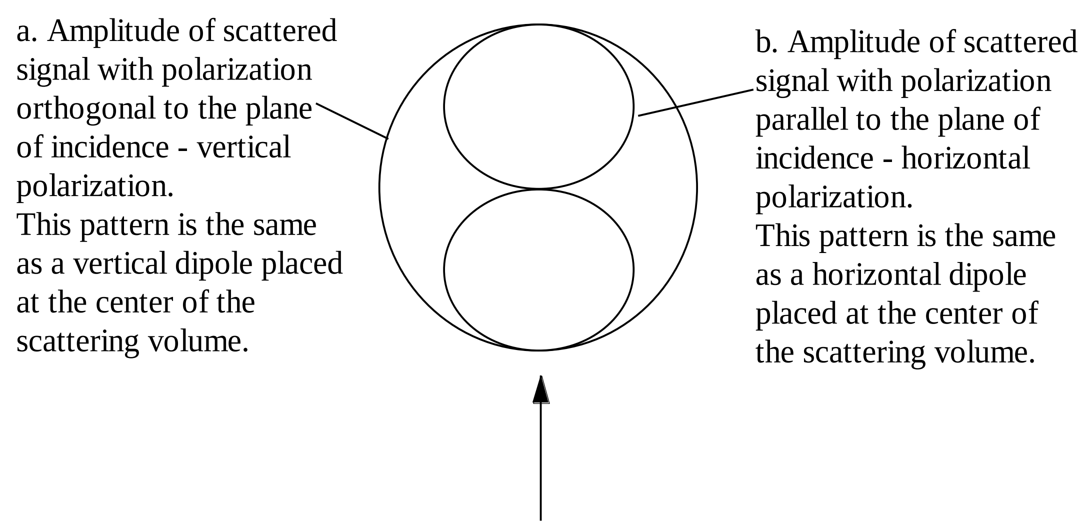

Figure 5. The amplitude of a signal emerging from a scattering volume as viewed from above - a. vertical polarization. b. horizontal polarization.

Consider transmitting with horizontal polarization. The “re-transmitter” has the same polarization as the transmitter. If the transmitter were pointing north into the scattering volume, then the scattered signal will look like a dipole oriented east west and radiating mostly north and south. Receiving stations north and south of the scatterer will get strong signals, but stations east or west of it will receive very weak signals or none at all. Stations in-between will receive some fraction (as in figure 5). In the last section of this paper, the consequences of the effects of polarization on rain scatter 10 GHz and higher frequency ham radio bands are presented.

When the wavelength/size ratio becomes smaller than 10, and especially when it goes below unity, the picture changes quite rapidly. Under these circumstances, the forward direction of scattering becomes stronger than back or side scattering. This is true for both polarizations. The polar plots of intensity are different for vertical and horizontal polarizations, but the forward scattering begins to rapidly dominate as the frequency goes up or the particle size goes up beyond a 1 to 1 ratio. In these situations the horizontal plot begins to look more like the vertical one, as you will see below. Note that there are changes in reflection as well as changes in re-radiation. At lower frequencies the dielectric properties of water will cause greater reflection, so the apparent back-scatter will be considerably greater in the 2 to 24 GHz region than in the EHF bands. This backscatter effect is not of much importance to amateurs who are most often trying to achieve DX where forward scattering is important. However, there are circumstances, such as intervening obstacles where backscatter QSOs are desired, and where 2 to 24 GHz communications can be more effective than some of the re-radiation plots suggest.

4 The Atmosphere and Water

Fluids such as gasses (the atmosphere) exhibit some heterogeneity at different scales. Consider the atomic level, where the nitrogen, oxygen and water molecules are essentially disruptions in the vacuum that they are imbedded. Even though they are small compared to a light wave, they do perform some scattering, resulting in color in the sky. At a larger scale, there are dust particles suspended in the air, and there are water particles of a variety of sizes including raindrops.

4.1 Water Particles in the atmosphere

Water in the atmosphere tends to clump into several ranges of particle sizes. Although the possible size of particles completely fills all size ranges from single molecules to the largest raindrop,

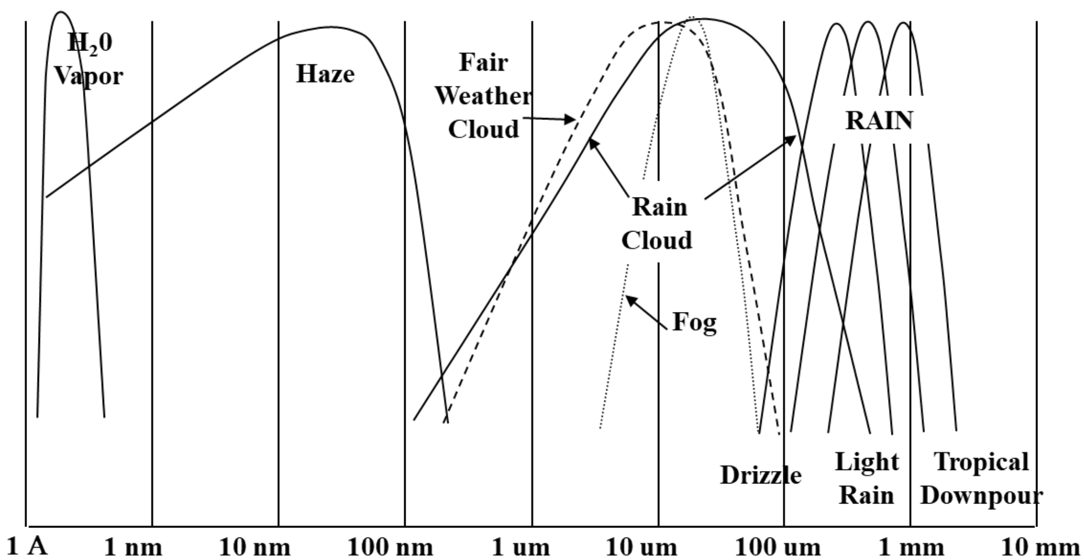

Figure 6. A chart of the distribution of water particle radii for different atmospheric phenomena

our observations of common natural states and our naming conventions describe specific particle size ranges. The first is water vapor - which is individual molecules that have properties similar to other atmospheric gasses. The next larger size is haze particles, which range from under .001 um (a thousandth of a micro-meter, just a few molecules stuck together) to 0.1 um (a few million molecules), and those in clouds range from .001 mm to 0.1 mm. Fog particles are within the bounds of the size of cloud particles.

Rain droplets range from about 0.1 mm to 1.5 mm (very light drizzle to tropical downpour) radius. Rain is in a good range for scattering of 10 GHz signals. Drop circumferences are 1/50 to 1/3 of a wavelength - and indeed it is the heavier rainstorms (with their larger rain drops) that give the best scattering returns.

4.2 The Refractive Index of Water

The refractive index of water is a function of frequency. At low frequencies it is quite high. From 5 GHz to 400GHz it drops from over 8 to about 2. From that frequency to light wavelengths it varies somewhat, eventually falling to a constant 1.33. Also, the refractive index is a function of temperature and changes when the water becomes solid (ice) or gas (vapor). The variety of temperatures found in rain in nature does not significantly affect the figures presented below.

It is probably worth mentioning that refractive indices have both a real and an imaginary part. For simplification, figure 7 shows only the magnitude of the index at a temperature of 20 C. The index changes very slightly at lower temperatures. The plots of scattering presented in Section 5 were all prepared using complex refraction of water at 20 C.

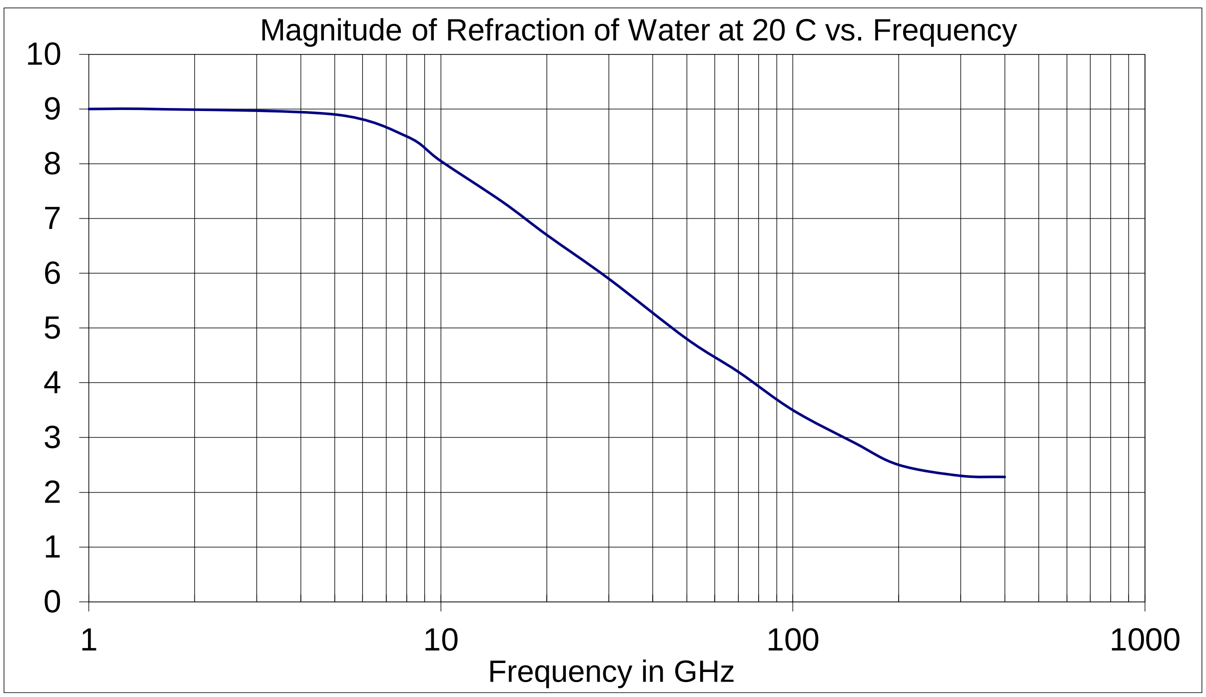

Figure 7. A simplified chart of the refractive index of water changing with frequency.

<u>Tropospheric Scattering</u>

Typical VHF and UHF scattering is caused (for the most part) by turbulence in the atmosphere. This turbulence is manifest in localized pressure differences with sizes that range from a few meters down to about 10 cm. This constitutes heterogeneity at a scale that ranges from a few cm to a few meters. Even though these refractive differences are small, it is turbulence that causes scattering of VHF and UHF signals. Scattering in the Troposphere, which we call "Tropo" scattering from turbulence exists at 10 GHz but it is weaker than on 1,296 MHz. We are concerned with rain scattering. There probably is some contribution to microwave Tropo by airborne dust and insects, but the author has not found a definitive reference on this topic.

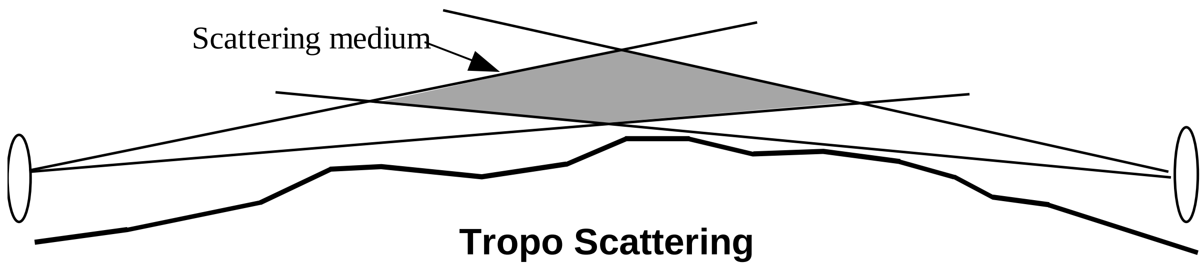

Figure 8. Typical propagation modes for microwave communication

We tend to use fairly narrow beam antennas on SHF and EHF - often with beam-widths of five degrees or less. You can think of the transmitted signal like a light beam from a searchlight. These antennas tend to "illuminate" smaller volumes of the scattering medium than broader beamed VHF arrays. This results in interesting short term fading effects and significant variability in signal levels day to day when the primary propagation mode is Tropo scattering. It is not uncommon to get a 3 to 6 dB boost from a low flying large commercial aircraft that happens to pass through the illuminated volume. The focused beam also allows one to efficiently illuminate a single thunderstorm a hundred miles away, making rain scatter DX a reality.

4.3 Practical use of Rain Scattering

On narrow-band microwave operations, we normally use horizontal polarization, which is parallel to the plane of incidence. Scattering for this condition follows the pattern shown above in figure 5. This means that in normal amateur radio microwave communications during rain scattering conditions, with everything else equal, some storms are in better positions than others (see Figure 9). The poorest scattering signals are apparent when the rain event is at a point that causes the two stations to aim at 90 degrees relative to one another. At shallower and greater angles, the signals increase. If amateurs want to maximize the likelihood rain scattering, then either vertical polarization should be used or rain cells that do not cause this 90-degree relation should be sought.

On a number of occasions the author and other New England stations W1FKF and W1RIL (now SK) have measured rain scattered signals of significant amplitude and over surprising distances. In the case of signals between W1RIL and W1FKF, where there is a fairly difficult obstruction (a nearby hill), rain scatter has offered over 10 dB and sometimes as much as 20 dB of signal boost. This can easily make the difference between not hearing the other station at all and being able to copy clearly.

One characteristic of rain scatter is Doppler shift. This phenomenon is manifest in a shift in frequency when the path between the transmitter and receiver is shortening or lengthening. Because the rain in a storm is being blown by winds, the scatterer is moving, the path length is changing, and the frequency is shifted. Usually, a CW note becomes quite "fuzzy" in its sound because the individual raindrops are moving at slightly different speeds and directions. The sound is very much like Aurora propagation on 6 or 2 meters - at times it can sound like strong noise. When looking for a rain scatter contact it is advisable to have the transmitting station send CW dashes, so that the receiving end can distinguish the noisy signal from the background noise.

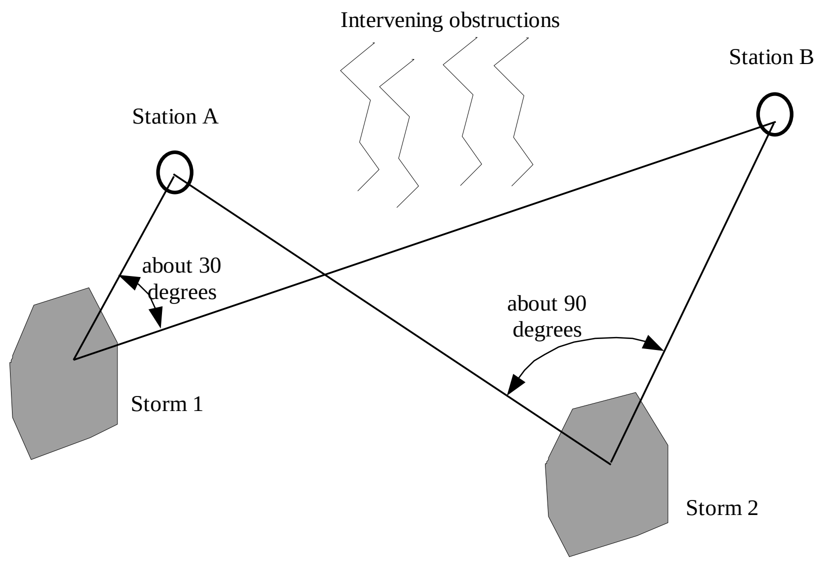

Figure 9. An example situation. The two stations are much more likely to communicate via storm 1 than storm 2 because storm 2 presents a 90 degree angle.

Because the wind will have one predominate direction, stations will notice some Doppler shift, even though the signal sounds quite fuzzy. Sometimes the wind speed is high enough to move the signal out of the pass-band!

In May of 1995, W1RIL and W1FKF pointed towards a developing thunderstorm with a round-trip distance of some 250 miles and noticed a Doppler shift of 4.1 KHz - which represents a wind/rain velocity of over 130 mph. As it turned out, this storm developed a devastating tornado. On another occasion, the author and these stations scattered their signals off a storm with a round trip distance in excess of 350 miles, and with signals strong enough for a phone QSO. Other stations have reported similar extended DX from rain scattering.

Over the years, we have come up with various ways of trying out rain scatter. If you are lucky enough to have a sked soon after your local TV station weather report, just look at the radar map - it will be the most current and local of any sources. You are more likely to need an up-to-date map at other times of day, so consider obtaining a radar application or weather application that includes weather maps for your cell phone. There are some programs designed to help amateurs use rain scatter (see references). Remember, when the two stations' paths to the storm are at 90 degrees, the signals will be weakest, but try anyway.

4.4 Snow Scattering

Snow scattering is very much like rain scatter, and at 10 GHz has approximately the same scattering effect for the same equivalent rainfall rate. However, most snowfall occurs at a slower equivalent rainfall rate than typical rain, so only the heavier snowstorms are likely to have significant snow scattering. Nonetheless, the author and other users of 10 GHz have observed snow scattering. At times is can be very effective at extending communications even though it is unlikely that hilltop expeditions would take advantage of this mode. Some of these sites are cold even in the Summer!

Many rain events, especially in the cooler months and in more gentle circumstances than thunderstorms create an effect called "brightening". The precipitation starts at high altitudes as snow. As the snow descends through warmer air it begins to liquefy slightly and the snowflakes clump together to make much larger wet flakes. This only happens in fairly calm atmosphere. Eventually these might re-freeze or melt to rain as they fall further towards the ground. At the layer where the large clumps are formed the particles are quite large and form a mirror-like surface. Although these tend to be fairly low in the atmosphere, they can provide very strong scattering like no other phenomenon. They also exhibit little or no Doppler shift as they only occur in relatively calm conditions. Perhaps brightening layers are not going to set records for scattering DX, but they can provide excellent signals.

4.5 Rain Scatter on 10 GHz and above

Although the author has participated in amateur radio contacts on EHF, none have used rain scatter. Rain scatter has been demonstrated numerous times with specialized cloud radars, which operate at 35 and 95 GHz. Such radars can distinguish between different size water particles in the cloud, and can easily characterize raindrops, ice crystals and sleet. This is all done with backscatter, and as can be seen, forward scatter can be stronger than backscatter at some frequency/raindrop size ratios.

The plots below show directional intensity for the upper ham bands at both polarizations and at different rainstorm conditions. In all cases the transmitter is at the left, and the plot is a view from above the scattering volume. The plots show both the vertical and horizontal polarization. The color version available in the file might be easier to interpret than the printed version here.

You might notice when carefully comparing plots that the same wavelength/size ratio does not always produce the same pattern. This is because the refractive indices of water change with frequency. Also, with a wide range of 40 or so dB in the chart it is possible to contain all the plots for a given frequency except that for the 10 GHz plot, the smallest raindrop size plot detail is lost. Therefore, a separate chart for 10 GHz and 0.5mm drops is provided.

The three raindrop sizes chosen correspond to the average rain drop size found in the three storm intensities with narrow distributions around those sizes. Plots show these three drop size effects separately on the same chart mostly to provide the reader with a handle on the effect of drop size at frequency. However, actual rain storms carry a distribution of drop sizes. A storm with narrow distribution around 0.5 mm raindrop radius is at the mean size of “drizzle”. This kind of storm would have rainfall of under 0.25 mm per hour (under 1/100 inch per hour). The 0.9 mm drop radius mean size would indicate a moderate storm of about 12.5 mm per hour (about ½ inch per hour), and the 1.4 mm drop radius characterizes the mean size of only the very heaviest of thunderstorms and tropical downpours of 100 mm per hour (4 inches per hour). A further plot is provided where size distribution covers the entire range representing the typical distribution of a moderate rain rate of 12.5 mm/h with a range of drop radii from under 0.2 to over 2 mm. This plot is meant to characterize a typical moderate rain storm. Very light rain storms and very heavy ones would be different.

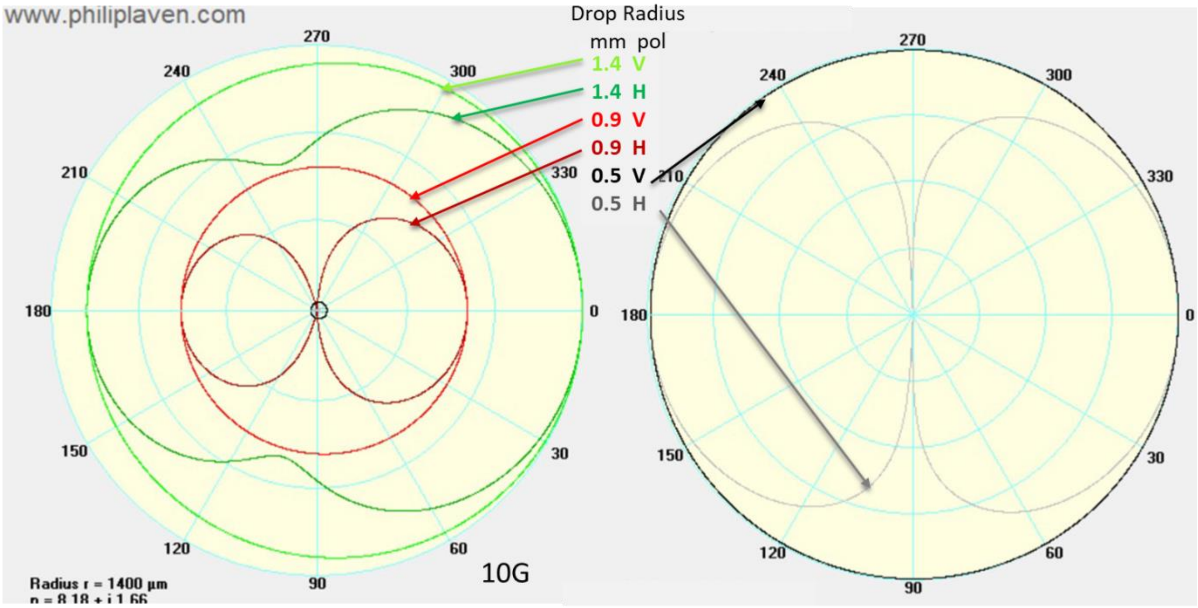

Figure 10. All these plots assume that the incoming EM wave is from the left. On 10 GHz it was impossible to see the shape from the smallest drop size on the same plot as the larger, but on all the others they “fit”. In this figure the smallest drop size plot is a small circle on the left plot, but is expanded to an entire plot by itself on the right.

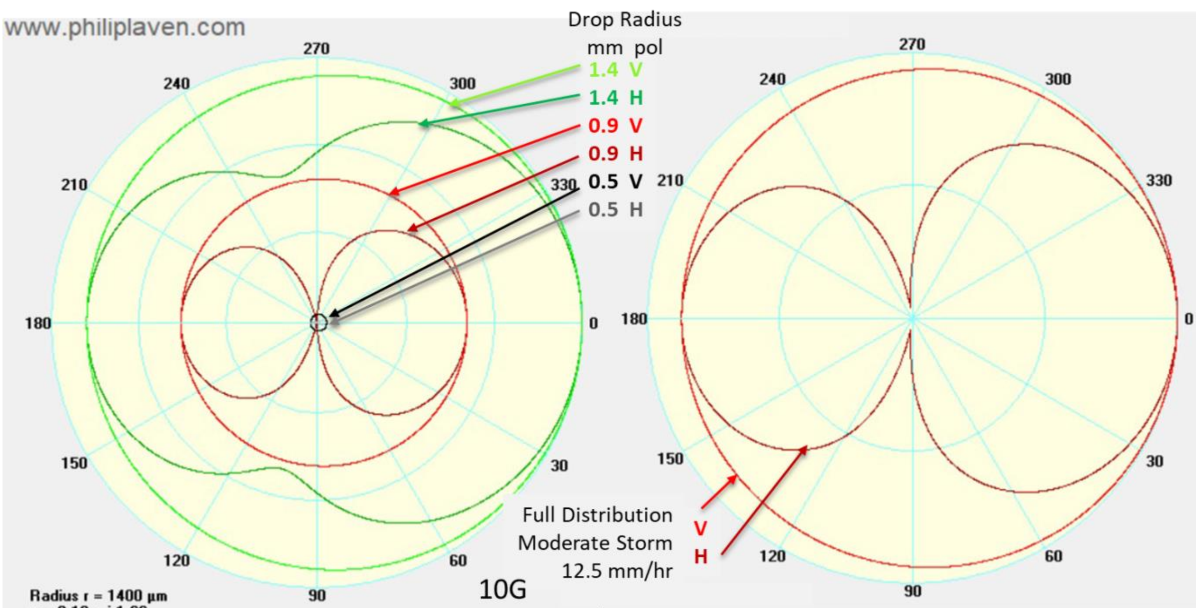

Figure 11. On this plot and all below, the left plot shows the scattering diagram for three very narrow ranges of raindrop size which are the mean of drizzle, a moderate storm and a tropical downpour. This helps visualize the differences caused by rain drop size. On the right is a more realistic plot that represents scattering from a typical distribution of drops from a moderate storm that rains at a 12.5 mm/hr rate (1/2 inch per hour).

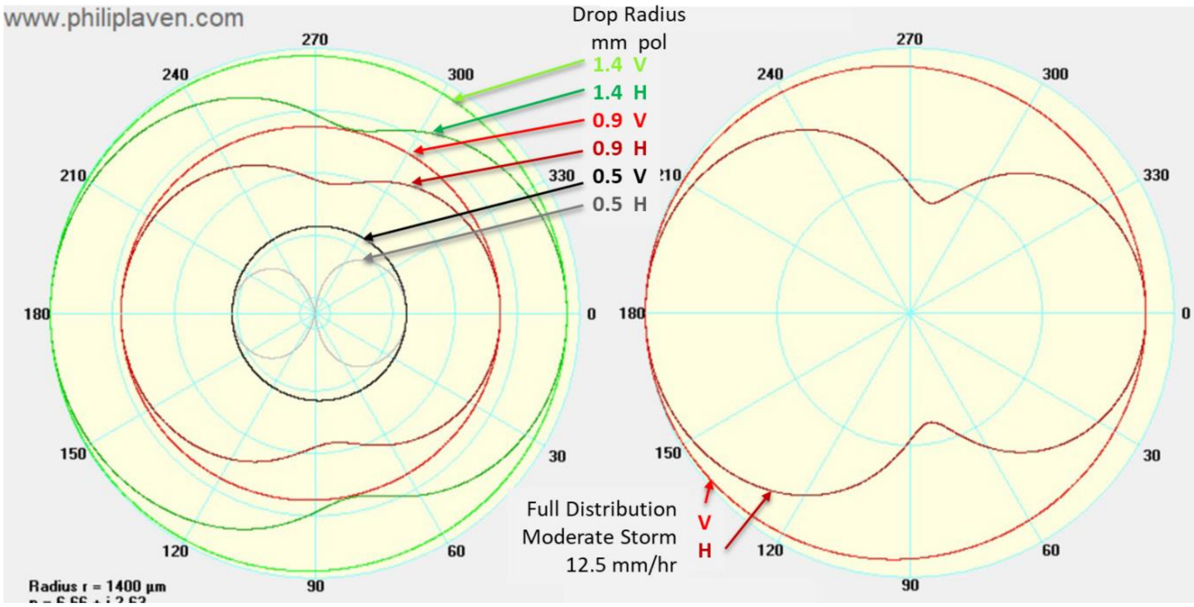

Figure 12. 24GHz plots of scattering. On left, three drop sizes in two polarizations. On the right, scattering with a drop size distribution as found in a moderate rain storm of 12.5mm/hr (1/2 inch/hr).

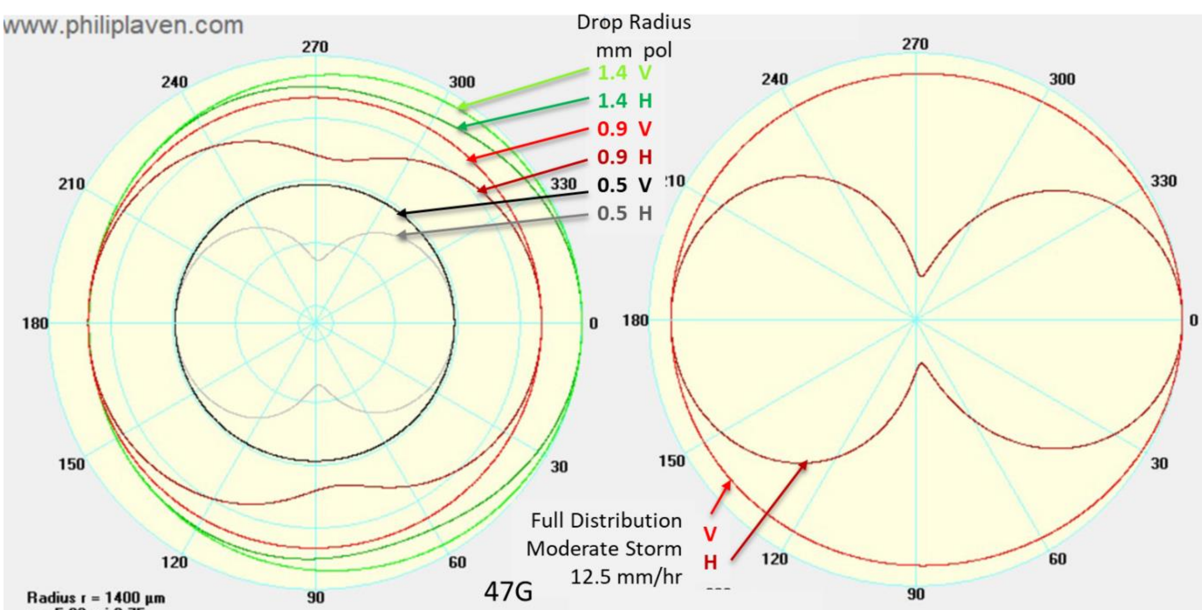

Figure 13. 47GHz plots of scattering. On left, three drop sizes in two polarizations. On the right, scattering with a drop size distribution as found in a moderate rain storm of 12.5mm/hr (1/2 inch/hr).

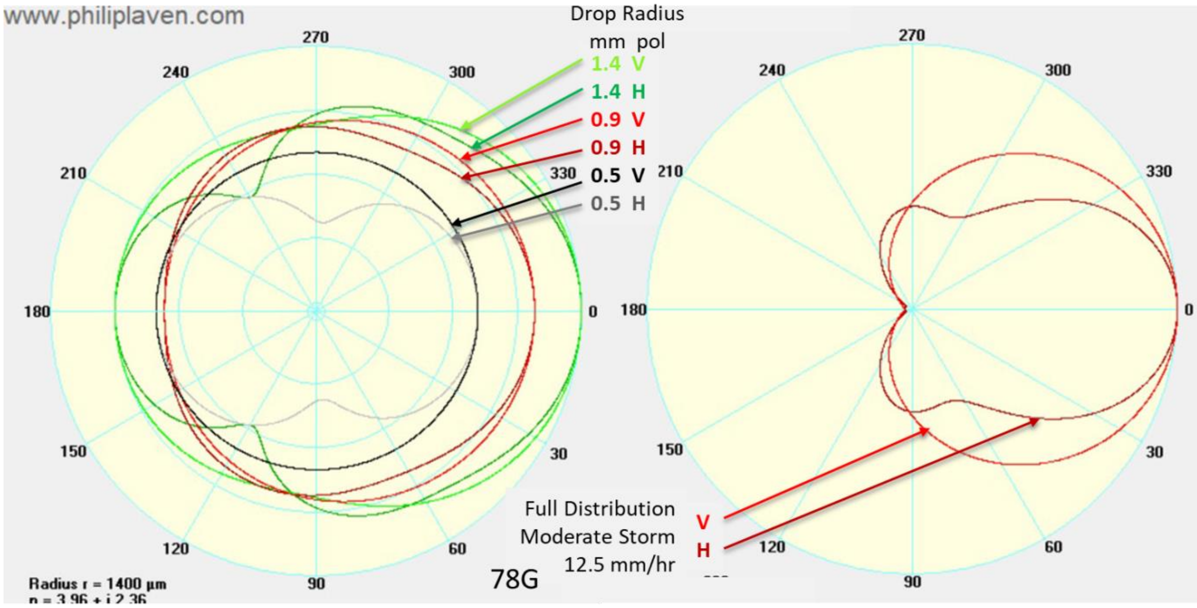

Figure 14. 78GHz plots of scattering. On left, three drop sizes in two polarizations. On the right, scattering with a drop size distribution as found in a moderate rain storm of 12.5mm/hr (1/2 inch/hr).

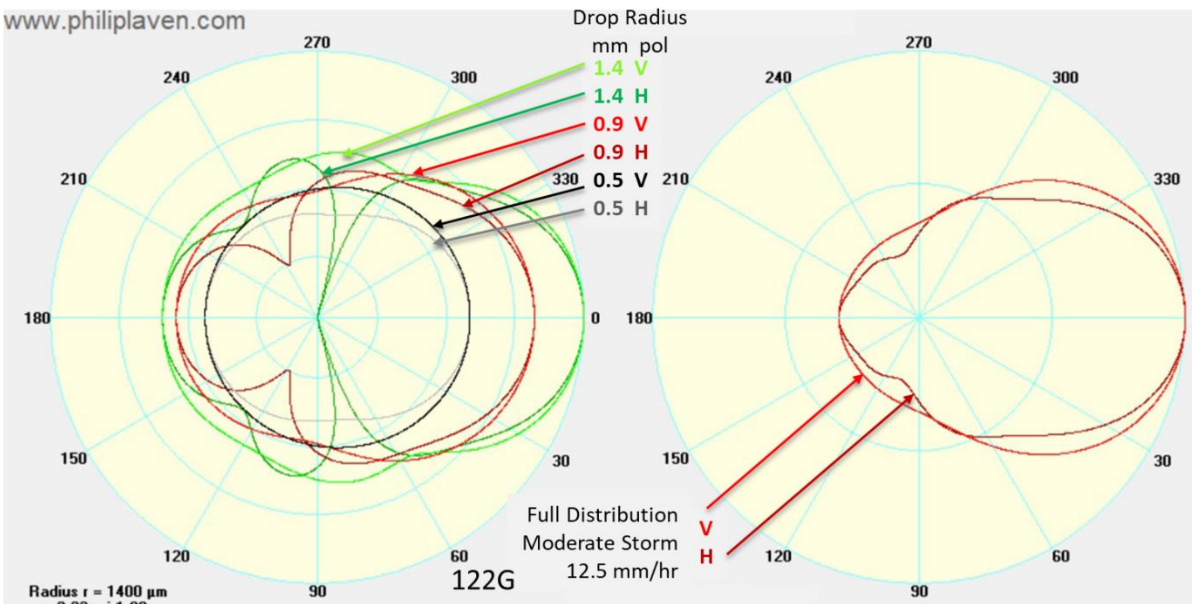

Figure 15. 122GHz plots of scattering. On left, three drop sizes in two polarizations. On the right, scattering with a drop size distribution as found in a moderate rain storm of 12.5mm/hr (1/2 inch/hr).

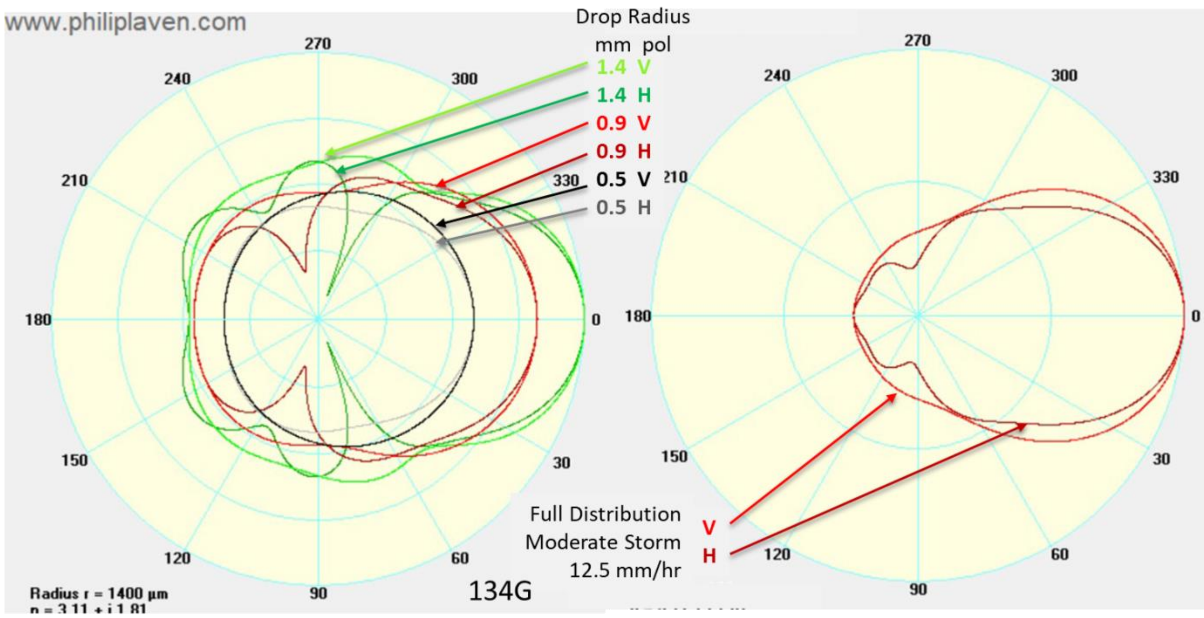

Figure 16. 134GHz plots of scattering. On left, three drop sizes in two polarizations. On the right, scattering with a drop size distribution as found in a moderate rain storm of 12.5mm/hr (1/2 inch/hr).

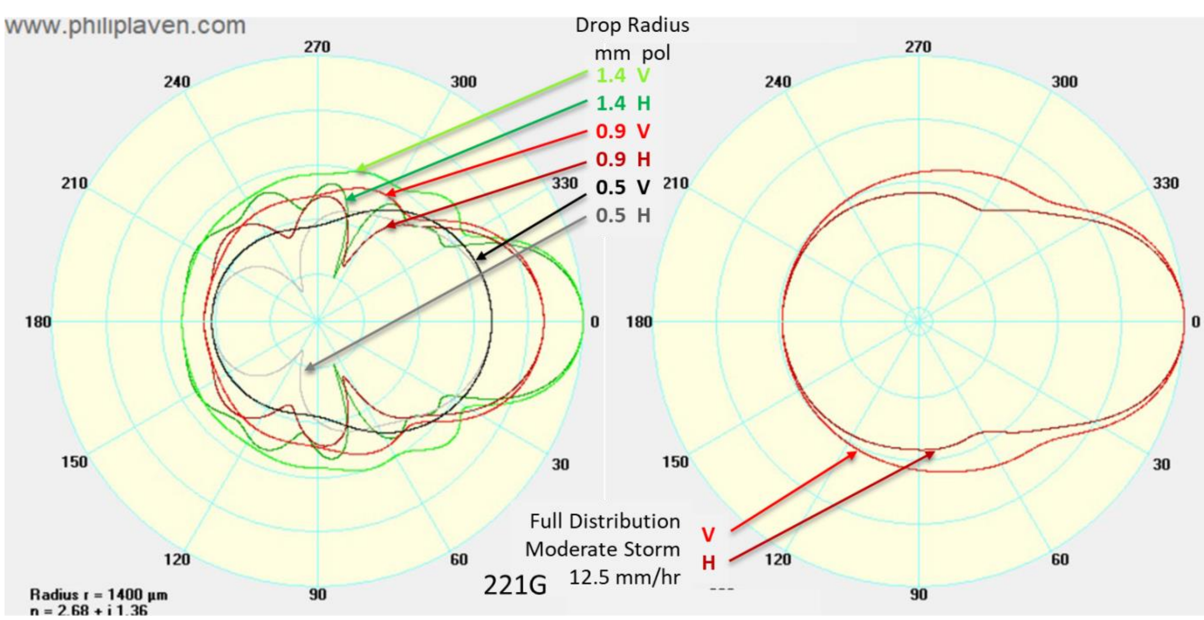

Figure 17. 221GHz plots of scattering. On left, three drop sizes in two polarizations. On the right, scattering with a drop size distribution as found in a moderate rain storm of 12.5mm/hr (1/2 inch/hr).

5 Attenuation

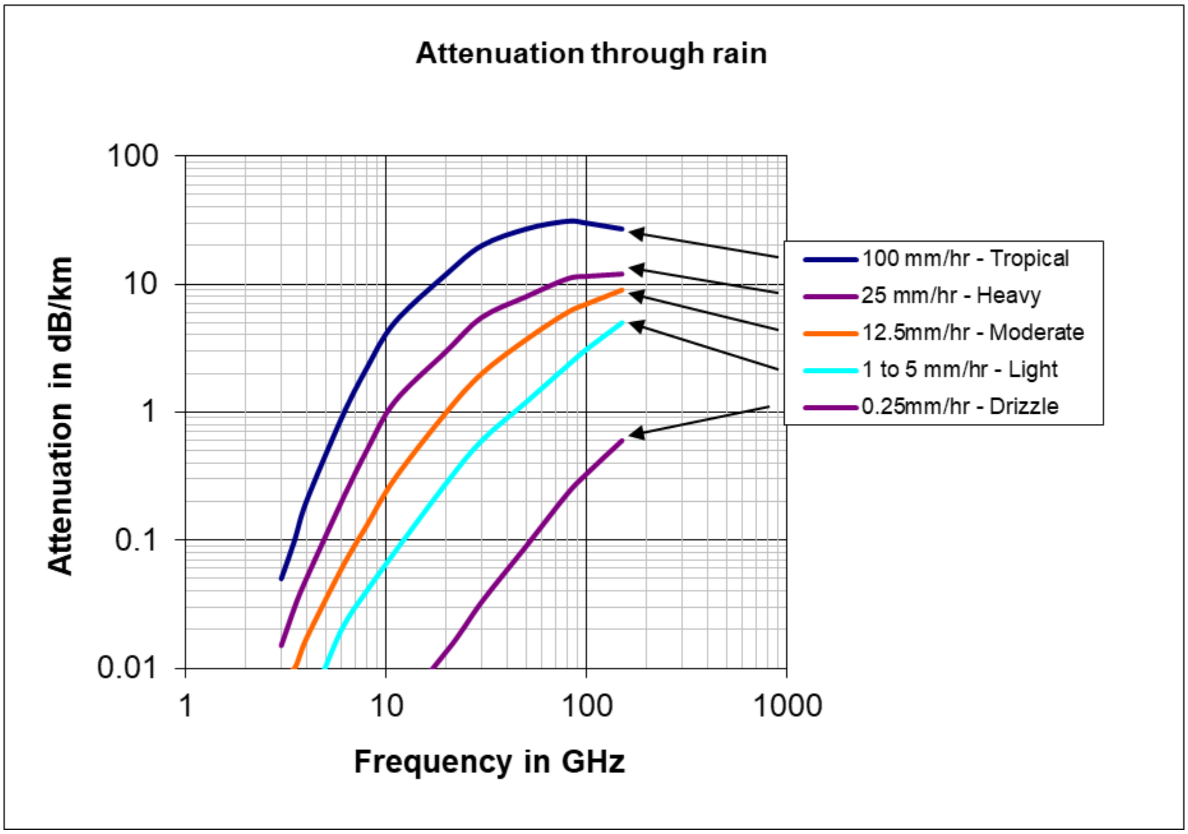

Figure 18. Attenuation through rain at different rain rates, according to total water content and frequency. This does not take into account atmospheric loss. It is due to rain alone.

Unfortunately, scattering alone does not tell us how well the signals will be heard at the other end of a link. Significant attenuation can occur in rain, especially as the frequency rises. Figure 18 includes information that the author could acquire, and does not include attenuation levels below about 0.01 dB/km, or frequencies below 3 GHz and above 145 GHz. These data should be useful in determining attenuation in most SHF and EHF situations.

As can be seen from Figure 18, significant path loss can occur through rain, especially heavy rain, which is the very condition that will improve forward scattering at EHF. Fortunately, thunderstorms are usually quite small, only covering a few kilometers. Therefore, the best situation for a rain scatter enhanced EHF contact would be a small and intense thunderstorm rain cell located midway between the two stations. Table 1, below, gives calculated data for scattering through a moderate storm where some atmospheric losses are included. This atmosphere was calculated at 50% relative humidity at just under 60F. Typical storms in the summer may have such characteristics, but to be fair, many will be at a lower temperature and higher relative humidity. The important dew point is likely to be around the range of this example, so the table is likely to be useful in practice as a first approximation.

Table 1. A table of effective attenuation in db/km of signals through atmosphere with rain falling at various rates. Here the atmosphere is set to 50% relative humidity, and the air temperature to 288 Kelvin, 15 Celsius, 59 Fahrenheit. The dew point is 5 Celsius, 41 Fahrenheit. Actual summer storm conditions may have a similar or higher dew point.

db/km	**Rain Rate mm/hr**												
GHz	**0.5**	**1**	**2**	**4**	**5**	**10**	**15**	**20**	**25**	**30**	**40**	**50**	**75**	**100**
10	0.019	0.027	0.045	0.088	0.112	0.248	0.403	0.571	0.749	0.937	1.336	1.760	2.908	4.157
24	0.214	0.287	0.435	0.732	0.881	1.629	2.379	3.131	3.884	4.639	6.150	7.665	11.459	15.263
47	0.556	0.816	1.276	2.090	2.468	4.199	5.777	7.263	8.685	10.056	12.687	15.202	21.142	26.736
78	0.996	1.444	2.181	3.391	3.926	6.255	8.258	10.077	11.769	13.366	16.351	19.128	25.462	31.209
122	1.757	2.308	3.180	4.560	5.157	7.690	9.810	11.700	13.435	15.056	18.047	20.793	26.950	32.439
134	1.654	2.217	3.104	4.501	5.104	7.653	9.778	11.668	13.401	15.018	17.996	20.726	26.835	32.267
221	3.031	3.616	4.526	5.939	6.543	9.073	11.160	13.003	14.683	16.244	19.107	21.718	27.522	32.647

6 Conclusion

So, what does this information about propagation mean to a ham? One thing is that a home station can be lots of fun, especially if there are other hams with home stations within 30 to 100 miles. It also means that portable operations can work in situations that would normally seem impossible - such as where there are mountains in the way. Rain may be a nuisance to operating, but it can be a welcome signal enhancer that lets you work around mountains and more than a hundred miles beyond normal range. Although moisture is usually the biggest enemy at EHF, one small intense thunderstorm, or a calm region of rain that provides the brightening effect, fortunately placed will probably enhance communications, and possibly be a propagation mode for record setting DX.

FOR MORE INFORMATION

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From Andy Flowers, K0SM:
http://www.n5dux.com/ham/files/pdf/Using Radar Data to Predict Rain-Scatter Paths.pdf

and an application devoted to Amateur Radio Rainscatter Activity
http://www.frontiernet.net/~aflowers/rainscatter/