Analysis of Rain Cell Size Distribution from Meteorological Radar Data for Rain Attenuation Studies

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Abstract - The ability of a radar to scan a wide area around the radar site and not just a particular path made it a very attractive for many types of investigations. Radar can be used to measure the rainfall rate indirectly. This is achieved by knowing the radar reflectivity and then converting them into rainfall rate. The S-band frequency of the meteorological radar ensures that propagation effects such as attenuation are negligible. Radar provides valuable information that is relevant in modelling rain-induced propagation effects. Radar also provides spatially and temporally continuous measurements that are immediately available at one location.

Rain cell size distribution is obtained from radar data. 'Virtual' microwave links of 20-km path lengths were constructed in the scanning area of the radar. However, rain cell size distribution from radar data is limited to 1-km integration size. This is due to the fact that the radar uses a range bin size of 1 km. The radar data is obtained from the Kluang Radar Station of the Meteorological Department of Malaysia.

This paper present an analysis of rain cell size distribution obtained from the meteorological radar data. Rain cell size is an important parameter in the study of attenuation of radio propagation through rain. This parameter is used for attenuation predictions, link budget estimation, microwave system planning, slant path rain attenuation modeling and remote sensing of the earth's surface, and have important applications in attenuation mitigation techniques such as space diversity. Analysis was done to find the rain cell size distribution.

1. Introduction

A very important factor that affects path reliability is rain attenuation. It also contributes in power budget and fade margin considerations. Thus, it is very important to properly quantify rain attenuation.

A rain event occurring in an area is not constant. Rain does not distribute evenly in a region experiencing precipitation. There arises a need to find rain cell size distribution to account for the non-uniformity of rain for larger distances. This is especially crucial in tropical regions as rain has been found to be more convective in nature rather than widespread. Tropical region also suffers heavier rainfall rates as compared to temperate regions.

To formulate the rain cell size distribution using rain gauges would requires many such devices to be installed. This would be very difficult and expensive. An alternative approach is to use radar data to obtain rain cell size statistics.

2. Methodology

The ability of a radar to scan a wide area around the radar site and not just a particular path made it a very attractive for many types of investigations. Radar can be used to measure the rainfall rate indirectly. This is achieved by knowing the radar reflectivity and then converting them into rainfall rate. The S-band frequency of the meteorological radar ensures that propagation effects such as attenuation are negligible [1]. Radar also provides spatially and temporally continuous measurements that are immediately available at one location.

The radar data utilized in this study were obtained from the Kluang Radar Station of the Meteorological Department of Malaysia. Using these data, 'virtual' microwave links of 20-km path lengths were constructed in the scanning area of the radar. These links are lined in the azimuthal scanning angles or radial lines of the radar. Not all radial lines of the radar scanning angles were used. Radial lines with the angles of 3, 6, 12, 15, 238, 241, 244, 247, 250, 294, 297, 300, 303, 306, 334, 337, 340, 343 degrees were chosen randomly in this study. The 20-km path length is chosen as it is seen as adequate to cover most rain

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cell sizes that occur in Malaysia [2]. However, rain cell size distribution from radar data is limited to 1-km integration size. This is due to the fact that the radar uses a range bin size of 1 km.

Figure 1 shows a pulse-position-indicator (PPI) radar scan for the Kluang radar station. The PPI gives the raining events as they occur.

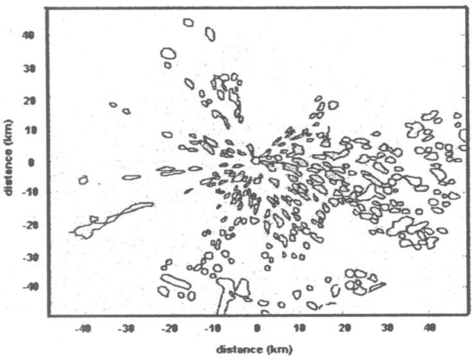

Figure 1: A Kluang radar station PPI scan.

For the determination of rain cell size, only rain cells that occurred inside the virtual links were considered. If a cell has a value in the first range bin or in the last range bin, it will not be considered. Thus, the maximum rain cell size considered is 18 km.

3. Result and Analysis

The result of this study is given in Table 1 and Figure 2.

Table 1: Rain Cell Size Distributions.

Rain cell diameter (km)	Total # of rain cells	Percentage
1	146661	70.507
2	30604	14.713
3	14811	7.120
4	6745	3.243
5	4276	2.056
6	1585	0.762
7	1209	0.581
8	738	0.355
9	393	0.189
10	213	0.102
11	157	0.075
12	178	0.086
13	118	0.057
14	116	0.056
15	82	0.039
16	57	0.027
17	41	0.020
18	24	0.012

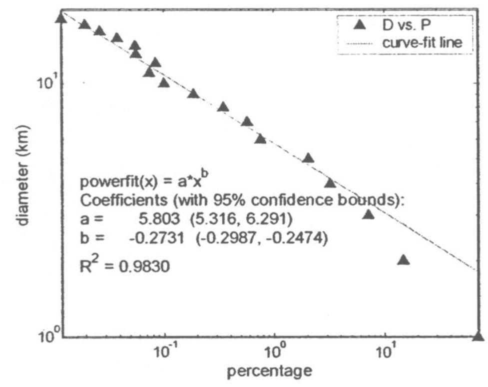

Figure 2: Rain Cell Size Distribution.

From Table 1 and Figure 2, it can be seen that about 70% of rain cells are of 1-km in diameter. This value is useful when mitigation technique such as site diversity is to be employed.

In Figure 2, the simple formula for the rain cell size distribution is given by

$$D = 5.803\ p^{-0.2731}$$

where D is the diameter of the rain cell in km, and p is the percentage of interest. For example, the diameter of rain cell size for 99.99 % of the time would be 1.65 km. Other researchers [3] in the tropical region concluded that rainfalls are mainly convective with relatively small diameters. These intense convective rains also usually occurred in relatively shorter period of time as compared to widespread rain. Values obtained in this study also agree very well with a previous study using a different type of measurement [4]. This information is useful for some communication system that may have the requirement of knowing rain cell size distribution.

4. Conclusion

Rain cell diameter will give a good indication for system planners doing attenuation mitigation technique such as site diversity application. Mitigation technique is important when high reliability of microwave link is needed. If attenuation exceeds the link budget of a link, then an alternative technique is surely required to overcome the attenuation problem. This is especially useful for satellite link where it's application has become more prominent as the communication community moves into higher spectrum of available bandwidth.

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