SOME RESULTS FROM A BISTATIC EXPERIMENT TO OBTAIN STATISTICS OF INTERFERENCE DUE TO PRECIPITATION SCATTER AT 11.2GHz.

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1. Introduction

Statistical data on hydrometeor scatter is of prime importance in the evaluation of interference between communication systems sharing frequencies. This paper presents some preliminary results from an 11GHz bistatic system designed to obtain such data, the experiment being one of those which are coordinated within the framework of the COST 210 European project. The experiment uses a fixed transmit antenna (transmitting continuously) at Chilbolton in Southern UK, and a receiver on a steerable 11m antenna at Baldock, some 131km NE of Chilbolton, which samples the scattered signals at a rate of 1Hz. The experiment began in July 1987, and we report here the results from the first year of observation. The path geometry is shown in Figure 1 and, as, depicted, there are in fact two paths, both in the vertical plane through Chilbolton and Baldock, corresponding to near-forward and near-backscatter situations. Table 1 summarises the main features of this experiment.

The transmit antenna elevation of 1° allows the main lobe (at the -3 dB point) to just clear the horizon, with the centres of the common volumes (CV) 3 km and 3.8 km above the earth in the forward and back scatter situations, respectively. Thus, in the events described here, ice scatter will contribute significantly to the total scattered power. Because the receive antenna has other commitments, data collection is restricted to 10 minutes in every hour, commencing at approximately 30 minutes past each hour. The forward scatter CV is observed on even hours, the backscatter CV on odd hours. The observing period is independent of weather, thus ensuring a statistically valid sample.

All recorded events were individually inspected as time series data and then compared with simultaneous observations from the UK Meteorological Office radar network. This was to identify and eliminate any non-hydrometeor-scatter events from the recorded data. Apart from occasional reflections from aircraft (particularly for the back scatter case) which can be identified by their characteristic sharp peaks, there were no other unwanted modes of propagation (eg clear-air or troposcatter into receiver sidelobes). In other words, it was apparent that, for the two chosen geometries, the signal at 11.2GHz was detected only when there was rain, ice or other types of hydrometeors present in the vicinity of the common volumes. Conversely, the scattered signal was almost always detected whenever there was any type of hydrometeor present in the two common volumes.

2. First year statistics

Figure 2(a) shows the first-year cumulative distributions for the two scatter cases from which certain features can be noticed. Firstly, the forward scatter configuration produces significantly higher signal statistics. This is primarily due to the difference in the altitudes of the two common volumes. As mentioned earlier, the CV in both cases lies predominantly in the ice region and hence the vertical fall in the reflectivity with height above the melting layer will give rise to significantly reduced scattered power for the back scatter geometry. Allowing for the difference in the free space loss, the curves differ by approximately 4dB at 1% time. This, over a height of 0.8km (difference in CV heights), gives a rate of fall of 5dB/km, which, assuming no ice attenuation, is somewhat less than the CCIR recommended 6.5dB/km [1]. However, a further allowance for the difference in the size of the common volumes (3.1×10^7 m^3 for forward and 3.6×10^7 m^3 for back) has to be made, which would tend to increase the observed rate of reflectivity fall. If the two CVs are assumed to be statistically filled in the same proportion, then the reflectivity fall becomes very close to 6.5dB/km.

The second feature from figure 2(a) is that the curves are relatively parallel from 1% down to 0.1%, but below this, the forward scatter curve appears to rise faster. This behaviour is particularly apparent in the summer months' data. Figures 2(b) and 2(c) separate the year-statistics into winter and summer month observations. The data from October 1987 up until March 1988 are catagorised as winter events and the rest as summer months. The smooth variation of the winter curves is consistent with the condition that the two CVs almost always lie in the ice region. The same will be true for the back scatter curve of the summer events, but for the forward scatter geometry, the altitude of the common volume (centred around 3km) can become comparable to the melting layer height for a small but significant percentage of time. In these cases, the scattered power will have rain and, more importantly, bright band contributions so that it is conceivable to have higher than expected rise in the signal levels. At 0.01% time, this effect, together with the reflectivity fall, gives rise to a difference of 9dB between forward and back scatter statistics.

Finally, figure 2(a) does not show any forward/back scatter asymmetry, as would be expected from, say, any differences in path attenuation. This asymmetry is predicted by the CCIR (Report 569-3) rain scatter model [2], for cases where significant parts of the scatter volume lie below the melting layer. Although this condition is not fulfilled during winter months (owing to the low freezing levels), one might expect the asymmetry to be present during the summer, particularly at very low time percentages. However, it is clear from the two curves in figure 2(c) that the effect of the bright-band contribution at low time percentages masks any attenuation differences, i.e. the path attenuation inside the scatter volume seems to have little effect on the overall statistics. This is due to not only the scattering medium not being predominantly rain but also the relatively low operational frequency.

3. Summary

This experiment was designed to simulate long-path co-channel interference between a typical radio-relay station and a ground-based satellite station. The most important point to note from the first year of results is that the interference signal due to hydrometeor scatter was well above the receiver noise level for at least 1% of the whole year.

The other more subtle points to note are :

(i) the variation of reflectivity per unit volume with height above the freezing level contributes primarily to the difference in the annual statistics of forward and back scatter
(ii) bright-band contributions give rise to higher than expected scatter signal for forward scatter geometry during summer months (but only below 0.1% time) and
(iii) the path attenuation inside the scatter volume for this particular link has little effect on the two statistics.

REFERENCES

[1] CCIR Report 563-3; "Radiometeorological data", Section 4.4, ITU, Geneva, 1986.
[2] CCIR Report 569-3; "The evaluation of propagation factors in interference problems between stations on the surface of the earth at frequencies above about 0.5GHz", Section 5, ITU, Geneva, 1986.

TABLE 1 Parameters of the experiment

Frequency : 11.2GHz
Polarisation : vertical
Tx-Rx distance : 131km
Scattering angles : 20° (Forward), 160° (backward)
Tx elevation : 1°
Rx elevations : 20° and 160°
Tx power : 1W
Tx antenna gain and half power beamwidth : 40.5dB & 1.6°
Rx antenna gain and half power beamwidth : 60dB & 0.18°
Rx bandwidth : 10kHz
Rx noise figure : 7dB

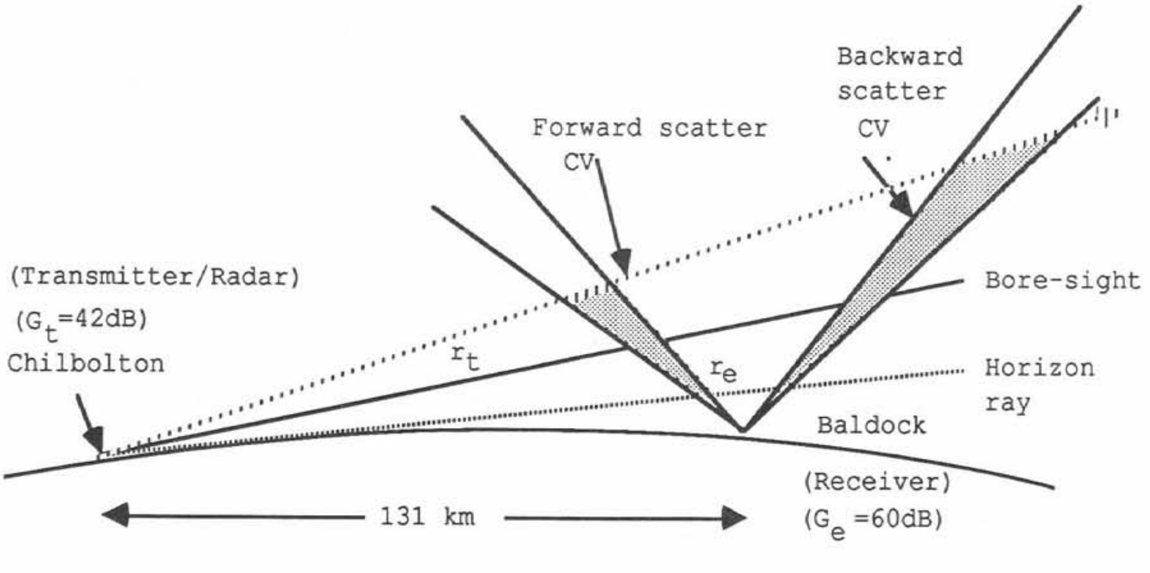

Figure 1: Chilbolton-Baldock Geometry

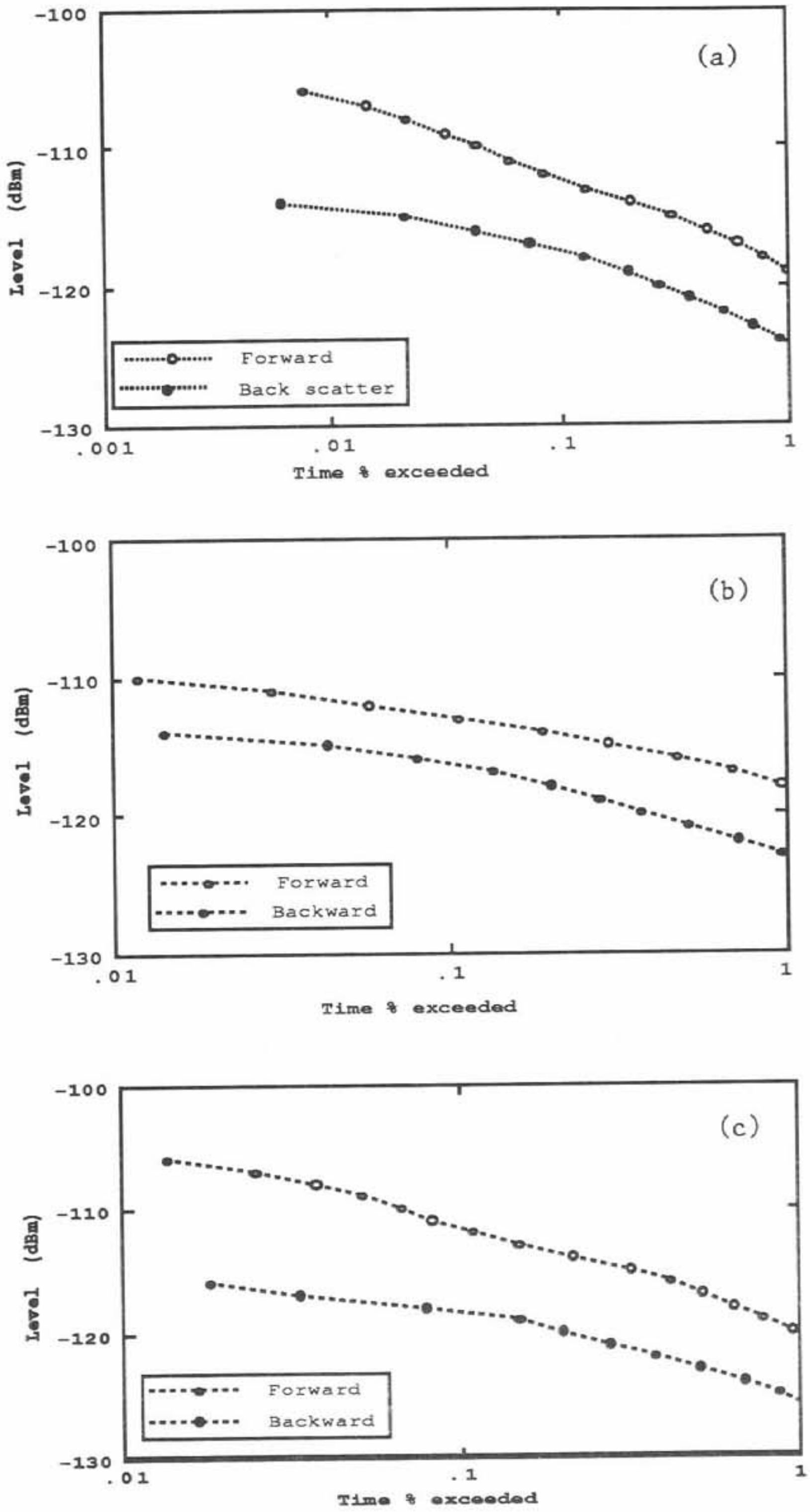

Figure 2 : Statistics of received power for
(a) one-year (b) winter months and (c) summer months