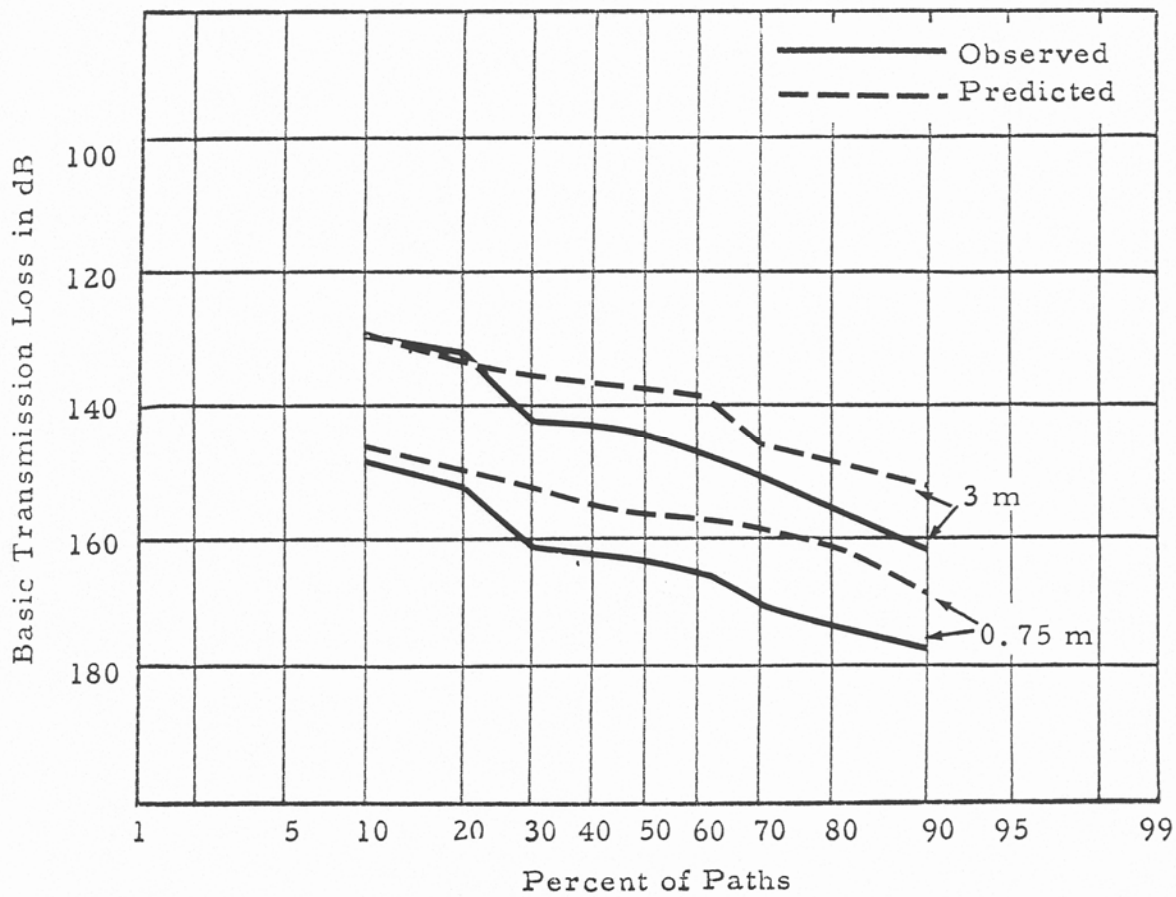
first group terrain ranges from rather smooth to quite hilly, with a median value Δh = 70 m. The terrain in the second group ranges from hilly to mountainous, with a median Δh value of 260 m. The terrain in the latter group is more rugged than that in the Wyoming area, while the former group is rather comparable to the measurement area in Idaho. The group of paths in rugged terrain contains an unusually large proportion of one-horizon paths where the obstacle is an isolated hill or ridge. The parameters tabulated are for antenna heights of 0.75 m. Raising the antennas to 3 m increases the horizon distances slightly and causes some reduction in median values of θ_e. Estimates of the effective antenna heights exceed the structural heights for more than half of the paths in rugged terrain and become quite large in a few cases.

Cumulative distributions of observed and predicted values of basic transmission loss and their differences are shown in figures 44 through 47. The 15 paths in the Ritzville area are rather too small a sample from which to draw conclusions but, as with the Idaho paths, they show that the predicted values are less than the observed values of transmission loss at both frequencies. The paths in rugged terrain on the other hand show less loss than is predicted. In the latter case the high proportion of single horizon paths suggest that the model for such paths should be revised.

3.4 Measurements and Predictions at VHF

A large measurement program with low antennas at frequencies of 20, 50, and 100 MHz was carried out in the Colorado plains and mountains and in northeastern Ohio. All of the measurements in Colorado were made from a common transmitter site, northeast of Boulder. Receiver sites were chosen at nominal distances from the transmitter without regard to propagation conditions. The measurements



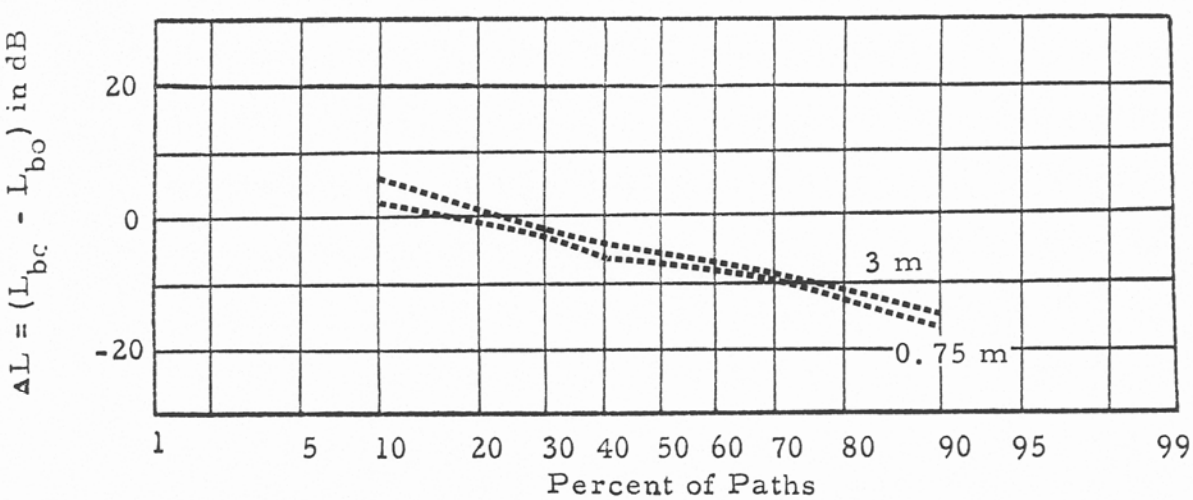


Figure 44. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Ritzville, Washington, f=230 MHz.

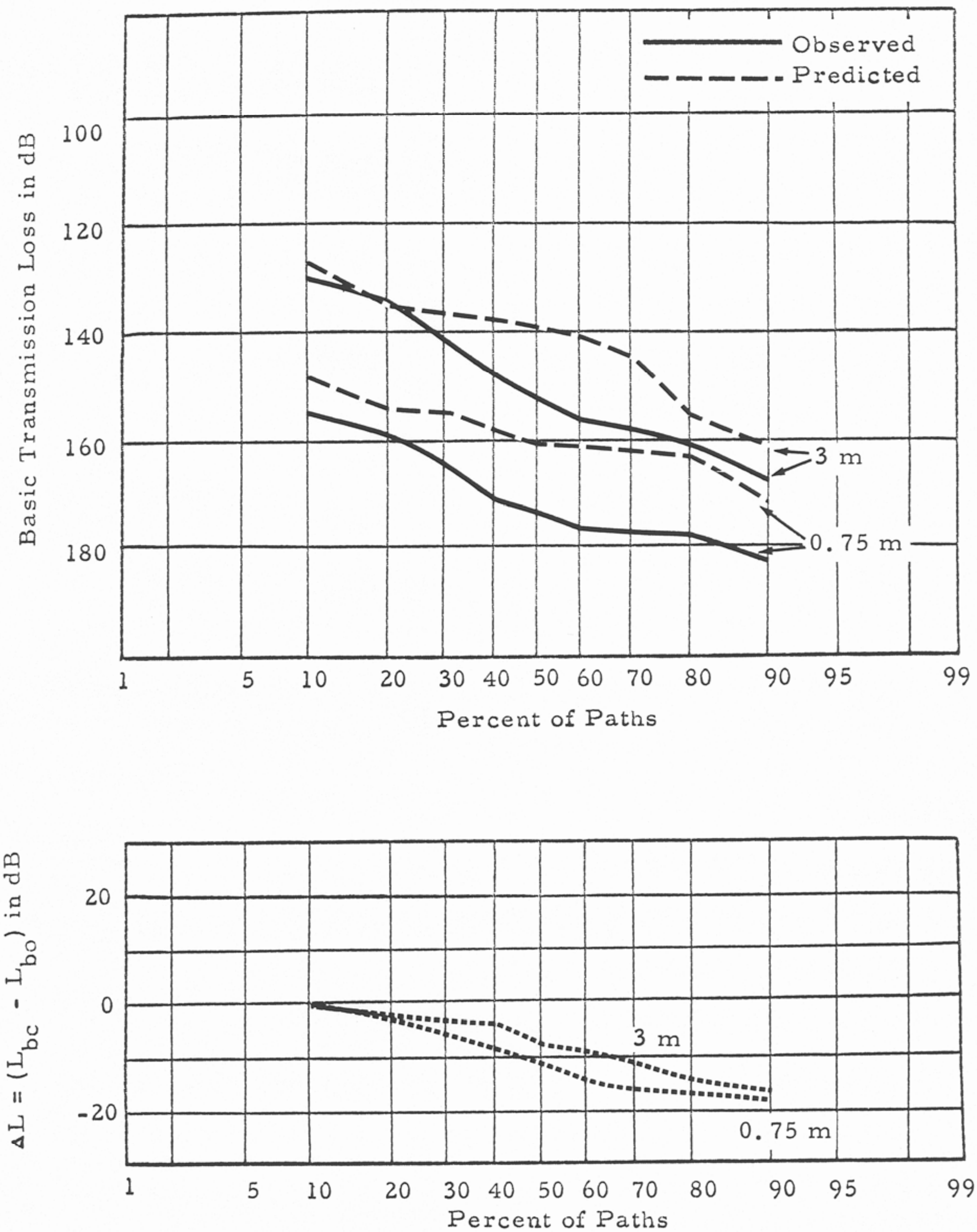
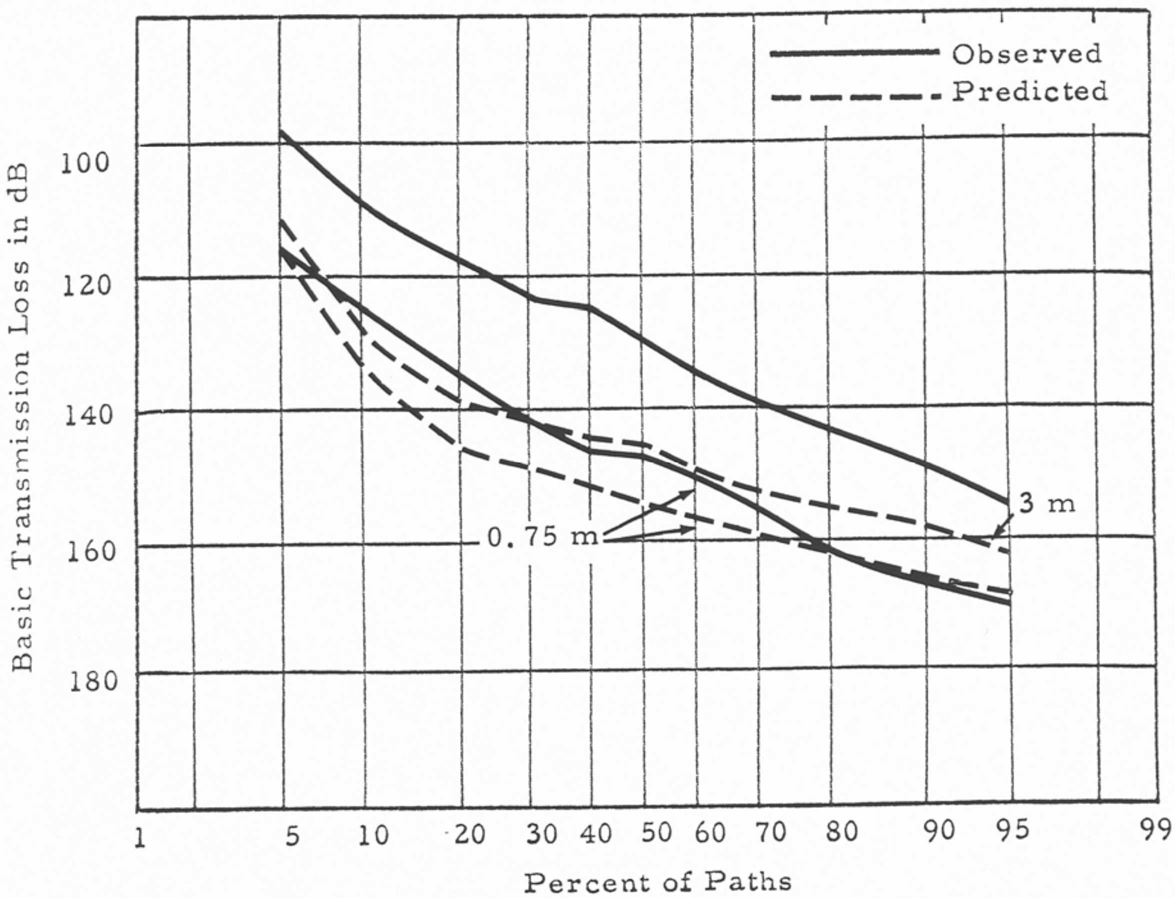


Figure 45. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Ritzville, Washington, f=416 MHz.



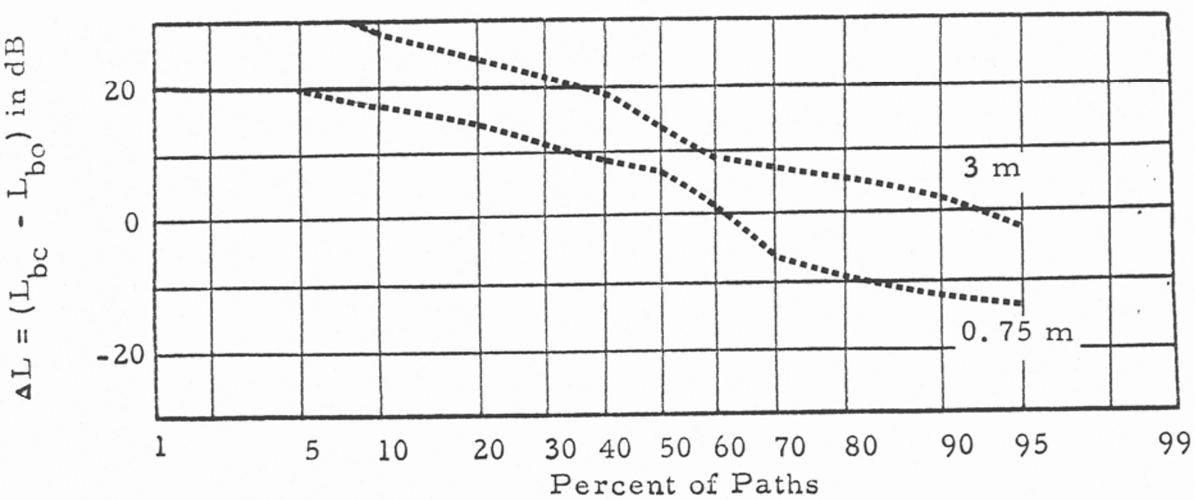


Figure 46. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Rugged terrain, Washington, f=230 MHz.

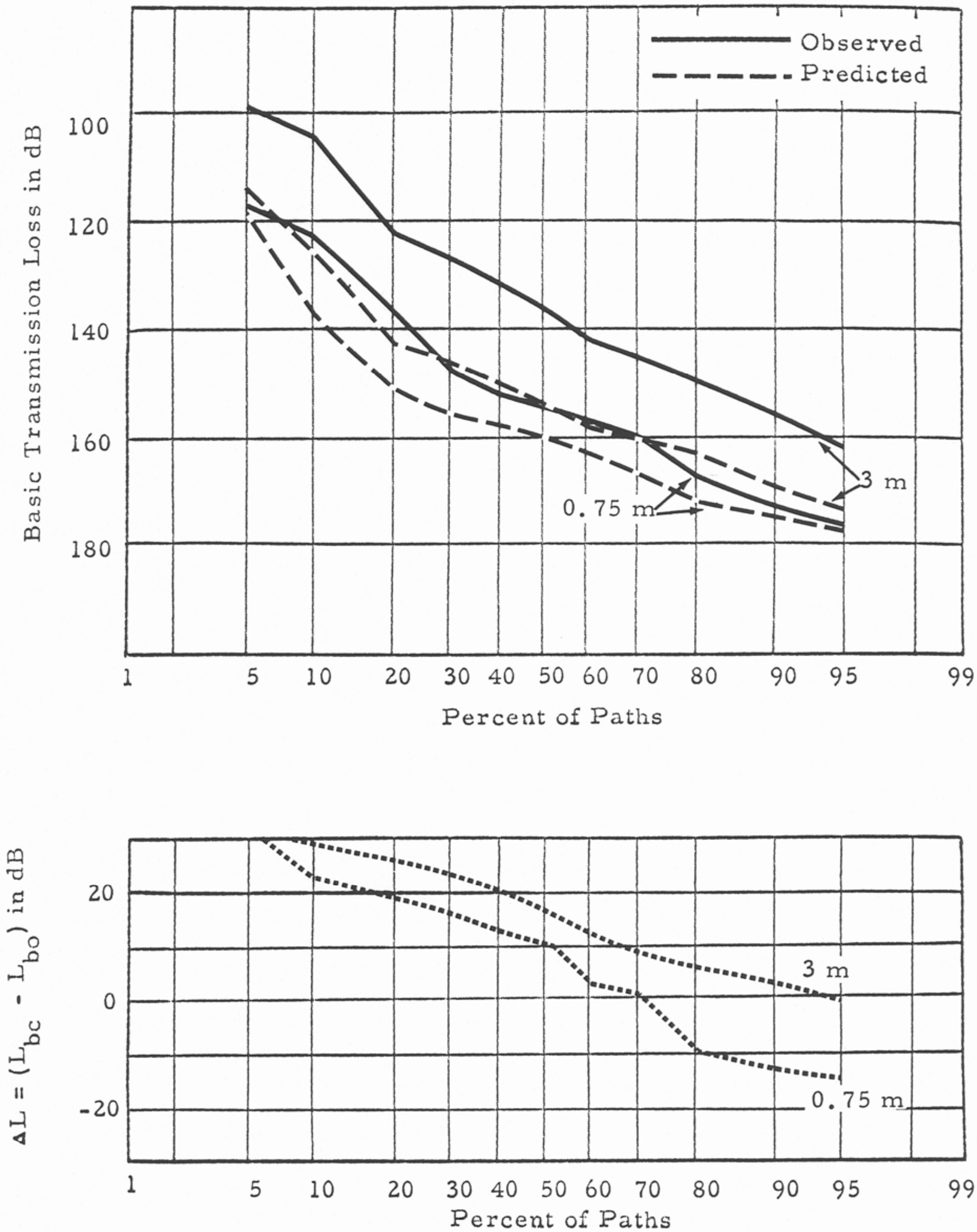


Figure 47. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Rugged terrain, Washington, f=416 MHz.

in Ohio were made from one central and five peripheral transmitters to receiver sites similarly selected at nominal distances from each transmitter.

Path profiles were read for about 490 paths and parameters calculated for each of them. Point-to-point predictions were then calculated for each path at each frequency and antenna height combination used in the measurement program. Tables 4, 5, and 6 show cumulative distributions of parameters for the following paths: 184 in the Colorado plains, 48 in the Colorado mountains, and 255 in northeastern Ohio. In all cases the parameters are for randomly selected "principal" sites, and where more than one receiver height was used the lower height is represented. Table 4 lists distributions of parameters in the Colorado plains for 184 paths with a median length of 50 km at 100 MHz, and 132 paths with a median length of 30 km at the lower frequencies. In this area the terrain is somewhat rolling, with a median value of the terrain parameter $\Delta h \simeq 95$ m but with a total range of nearly 300 m which corresponds closely to the terrain characteristics of the Ohio area. The Colorado mountain paths are over the most rugged area considered in this report, with a median $\Delta h \simeq 580$ m and values ranging over 1500 m. The advantageous siting of the transmitter in the Colorado plains is indicated by the median d_{L1}, which is much larger than the median d_{L2} for the randomly selected receiver sites. The same advantage is observed in the mountains paths, but to much less an extent in Ohio where six transmitter sites were chosen.

Figures 48 through 53 show cumulative distributions of basic transmission loss, observed and predicted, and of their differences at frequencies of 20, 50, and 100 MHz for each group of paths. In each case the measurements with vertical polarization are considered, and at 100 MHz receiver heights of 3 and 9 m are shown. The data at

Table 4. Cumulative Distributions of Path Parameters, Colorado Plains

Parameter	Min	10	20	30	40	50	60	70	80	90
					Percentage					
	100 MHz, h_{g1} = 4 m, h_{g2} = 3 m, 184 paths									
d	0.6	5.0	13.0	26.6	30.2	49.6	49.9	50.4	80.0	80.3
Δh	1.0	57.9	68.7	78.7	87.0	96.5	106.7	128.8	151.7	197.2
d_{L1}	1.0	2.6	9.0	10.3	11.3	12.1	16.2	21.6	24.8	29.4
d_{L2}	0.5	0.5	1.0	1.5	2.0	3.5	6.2	10.0	19.0	28.8
d_L	2.0	9.5	12.1	13.7	19.2	22.6	28.2	30.2	37.6	49.8
θ_e	-6.5	-3.4	-1.6	0.1	3.6	5.6	8.6	12.1	16.9	25.2
	26 line-of-sight, 34 1-horizon paths									
	50 MHz, h_{g1}=4 m, h_{g2}=0.55 m, 132 paths									
d	0.6	5.0	9.6	19.6	20.0	30.0	30.2	49.6	49.8	50.0
Δh	1.0	47.3	69.6	81.4	90.0	97.8	107.2	120.1	147.2	187.8
d_L	2.0	5.0	9.8	12.1	13.7	18.6	22.1	29.0	30.1	39.3
θ_e	-4.5	-2.0	0.1	2.0	5.2	9.4	11.2	17.0	22.1	34.2
	22 line-of-sight, 28 1-horizon paths									
	20 MHz, h_{g1}=3.3 m, h_{g2}=1.3 m, 132 paths									
d_L	2.0	5.0	9.9	12.4	14.4	19.3	22.6	29.3	30.2	41.0
θ_e	-4.5	-2.2	0.4	2.6	5.6	8.9	11.0	16.3	20.7	34.6
	24 line-of-sight, 30 1-horizon paths									

Table 5. Cumulative Distributions of Path Parameters, Colorado Mountains, 48 Paths

Parameter	Min	10	20	30	40	50	60	70	80	90
					Percentage					
				100 MHz, h_{g1}=4 m, h_{g2}=3 m						
d	5.0	9.8	19.6	19.7	29.3	30.1	30.4	49.8	50.0	50.2
Δh	253.4	362.4	429.9	477.3	508.9	579.5	629.1	720.5	811.6	957.8
d_{L1}	3.4	4.4	4.5	4.5	6.6	7.8	9.2	11.4	13.5	15.3
d_{L2}	0.5	0.5	0.5	1.0	1.4	1.5	2.5	3.0	5.8	10.4
d_L	4.9	5.0	6.6	8.1	10.1	11.6	12.8	15.0	16.8	22.1
θ_e	22.9	56.0	60.7	75.6	112.2	139.4	155.2	166.1	198.6	298.4
				no line-of-sight, 5 1-horizon paths						
				50 MHz, h_{g1}=4 m, h_{g2}=0.55 m						
d_L	4.9	5.0	6.6	8.1	10.1	11.5	12.8	15.0	16.8	22.1
θ_e	23.3	57.3	62.5	77.2	115.9	140.4	158.9	168.0	203.0	302.0
				no line-of-sight, 5 1-horizon paths						
				20 MHz, h_{g1}=3.3 m, h_{g2}=1.3 m						
d_L	4.9	5.0	6.6	8.1	10.1	11.5	12.8	15.0	16.8	22.1
θ_e	23.4	57.3	62.1	76.8	115.2	140.2	157.8	166.9	202.1	301.0
				no line-of-sight, 5 1-horizon paths						