may be the explanation of these differences. This possiblity should be further investigated when more of these paths have been studied.

3.3 Wyoming, Idaho, and Washington

The measurements in Wyoming, Idaho, and Washington were limited to frequencies of 230 and 416 MHz, with very low antennas. The transmitting antennas were fixed at 0.75 and 3 m above ground, while the receiving antennas were raised continuously from 0.75 to 3 m. Both transmitting and receiving units were mobile, and sites were chosen without regard to propagation conditions.

Cumulative distributions of parameters for 47 paths in Wyoming and 30 paths in Idaho are listed in table 2. The parameters listed are for transmitting and receiving antenna heights of 0.75 m. Increasing both antenna heights to 3 m has little effect on the path parameters d_{L1}, d_{L2}, d_L, and θ_e. However, with the lower heights we assume that the effective heights are equal to the structural heights, while with the 3 m antennas effective heights are estimated. These effective heights exceed the structural heights for about half of the paths in Wyoming, and for a few paths this increase is more than 30 m. The estimated effective heights in Idaho exceed the structural heights for about one-third of the paths.

The computer model is limited to situations where the distance from each antenna to its horizon is not less than one-tenth of the corresponding distance $d_{LS1,2}$ over a smooth earth. With antenna heights of 0.75 m, $d_{LS1,2} \simeq 3.5$ dB and their sum $d_{LS} \simeq 7$ dB. Table 2 shows that for many paths, especially in Wyoming, the horizon distances are less than one-tenth of these smooth earth values. The prediction

Table 2. Cumulative Distributions of Path Parameters, Wyoming and Idaho

Parameter	Min	10	20	30	40	50	60	70	80	90
					Percentage					
	Laramie Range, Wyoming, 47 paths, $h_{g1}=h_{g2}=0.75$ m									
d	3.6	6.0	7.8	8.8	10.0	13.9	17.6	19.8	21.9	26.1
Δh	53.8	65.5	87.8	99.4	112.0	120.4	136.7	159.2	183.4	204.0
d_{L1}	0.1	0.2	0.4	0.6	1.3	1.5	1.7	2.9	4.4	8.8
d_{L2}	0.1	0.2	0.3	0.4	0.6	1.1	2.0	3.1	4.9	7.8
d_L	0.2	0.7	1.8	2.0	2.3	2.9	4.2	5.6	8.4	15.8
θ_e	-3.0	12.5	19.5	23.3	28.9	36.6	49.4	53.0	71.7	88.4
	2 line-of-sight, 8 1-horizon paths									
	Idaho, 30 paths, $h_{g1}=h_{g2}=0.75$ m									
d	10.8	15.0	17.1	18.4	20.4	20.8	21.4	23.4	27.2	32.8
Δh	8.6	24.8	46.6	52.8	59.2	62.8	70.4	81.3	102.4	116.2
d_{L1}	0.3	1.2	2.0	2.4	3.7	8.0	11.1	13.9	15.2	19.8
d_{L2}	0.4	1.3	1.5	2.4	3.6	5.1	6.6	8.4	10.2	13.2
d_L	4.7	5.0	10.5	12.3	13.0	14.8	16.2	17.6	20.5	24.0
θ_e	-3.4	-0.1	1.8	3.9	7.0	11.5	15.3	17.3	20.2	24.2
	1 line-of-sight, 9 1-horizon paths									

model was modified to allow for this as follows:

$$\text{for } d_L < d_{LS} \qquad \Delta L_c = 10 \log_{10} (d_{LS}/d_L) \text{ dB}, \tag{2a}$$

$$\text{for } d_L \geq d_{LS} \qquad \Delta L_c = 0 \text{ dB}. \tag{2b}$$

Then for low antennas (less than 3 m) over irregular terrain, the calculated median basic transmission loss is modified by adding ΔL_c to the computed value L_{bc} for transhorizon paths.

Figures 40 and 41 show cumulative distributions of basic transmission loss observed and predicted, and of the differences ΔL between these values for each path for frequencies of 230 and 416 MHz in Wyoming. Figures 42 and 43 present the same information for the paths in Idaho. For both the 0.75 and 3 m antennas the predicted values show good agreement with measurements. In all cases the standard deviation of ΔL is about 9 or 10 dB. This represents the location or path-to-path variability caused by factors not included in the prediction model. In Idaho the predicted values with antenna heights of 0.75 m tend to underestimate the transmission loss. The reason for this is not clear at present.

The measurement paths in Washington fall naturally into two groups, the first consisting of 15 paths near Ritzville where the terrain is relatively smooth farm land, the second of 53 paths in rugged and mountainous terrain. Of the latter group 14 paths have a common receiver site in the Spokane river valley near Fort Spokane and extend into the surrounding forested, mountainous terrain, while the remaining paths are in rugged country west of Ritzville where steep hills, coulees, and deep canyons with almost vertical walls occur. Distributions of parameters for these two groups of paths are listed in table 3. In the

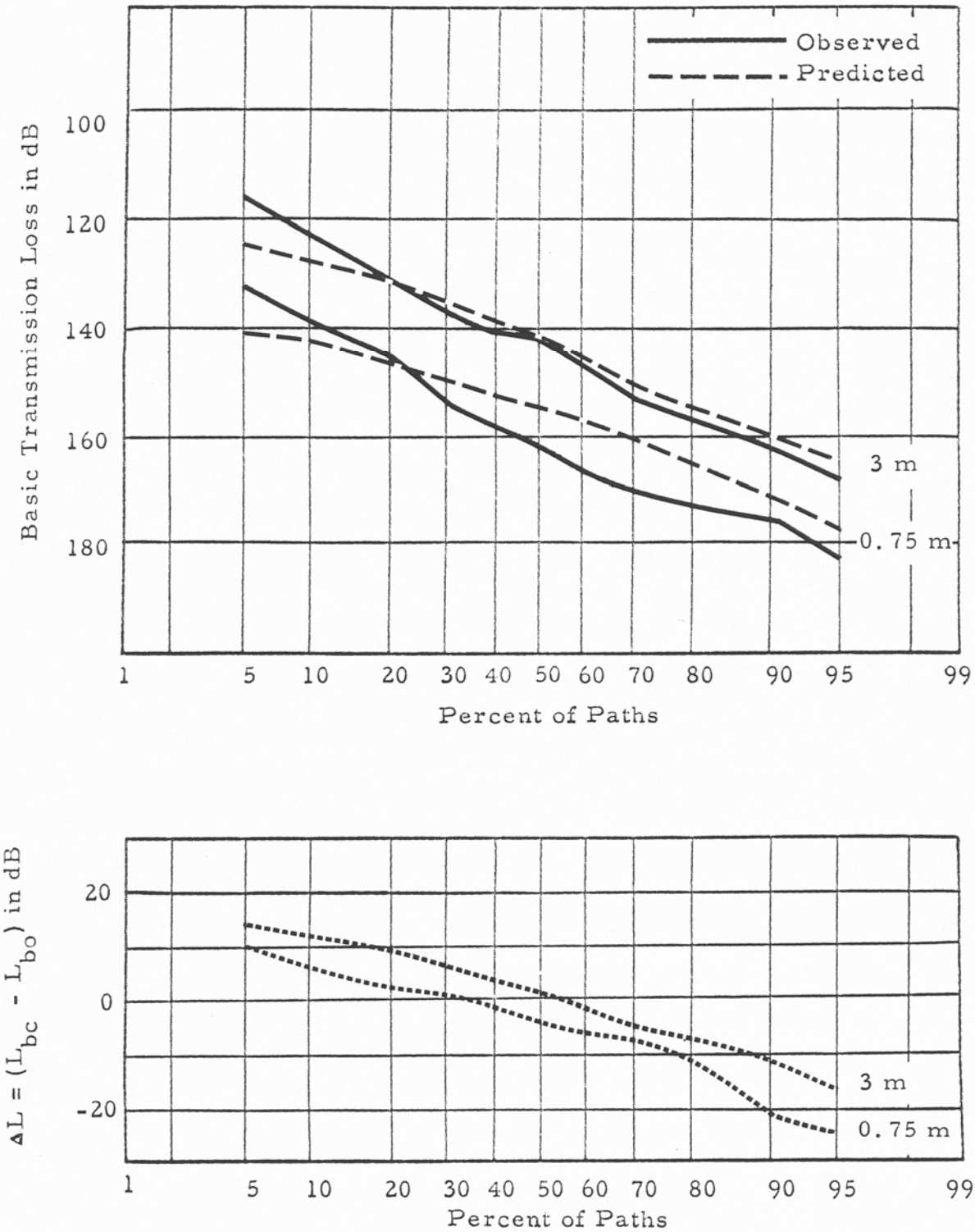


Figure 40. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Laramie range, Wyoming, f=230 MHz.

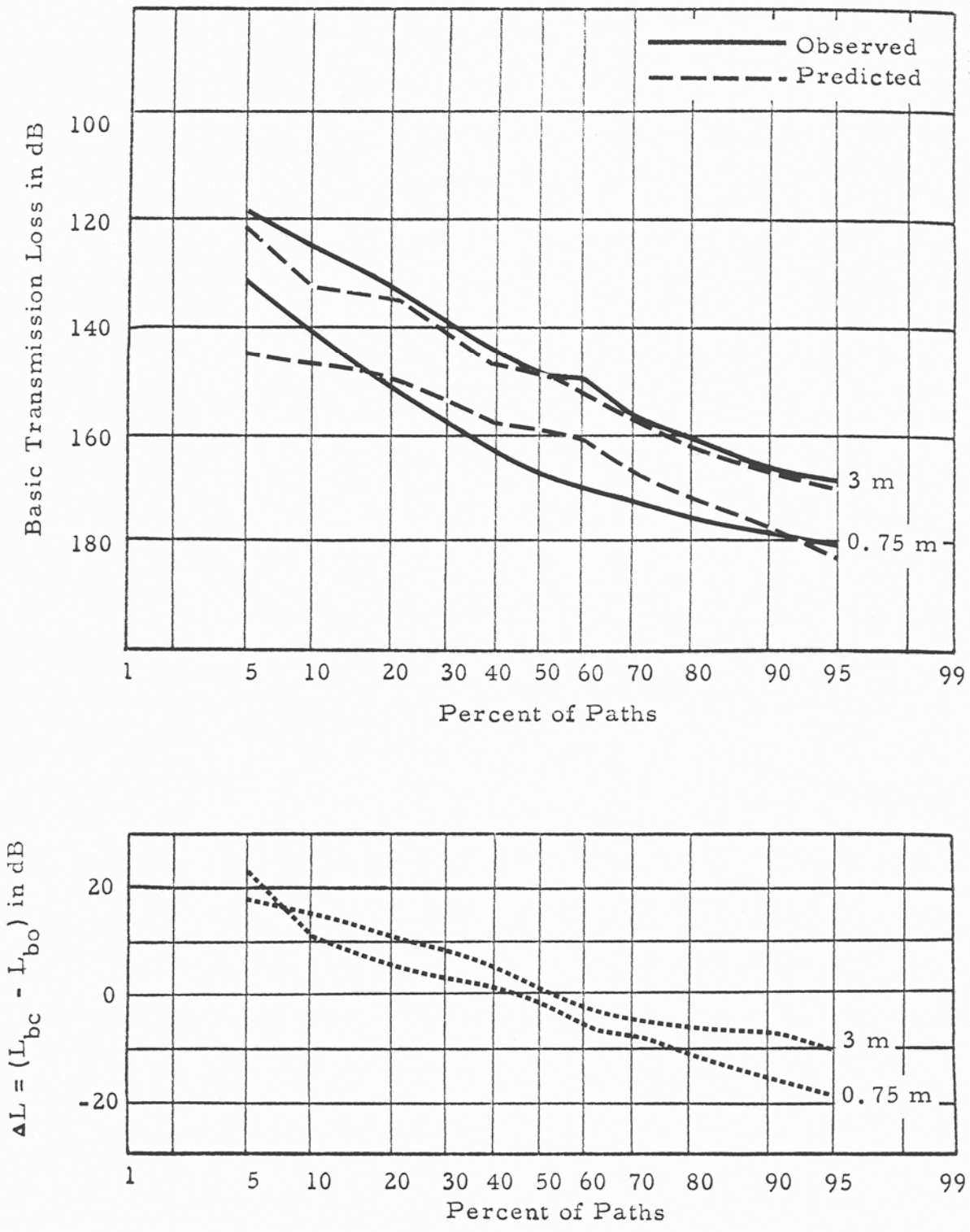


Figure 41. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Wyoming, f=416 MHz.

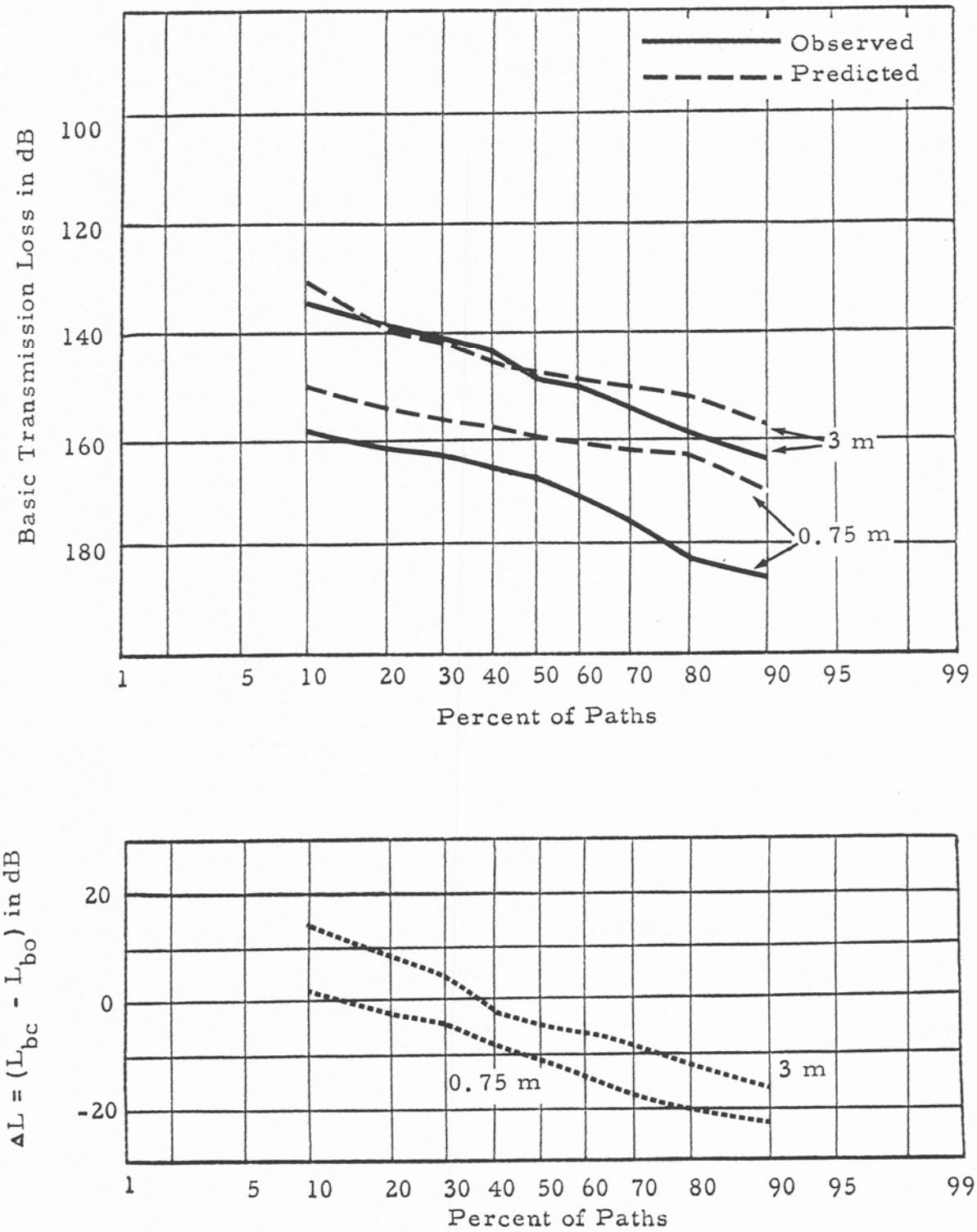
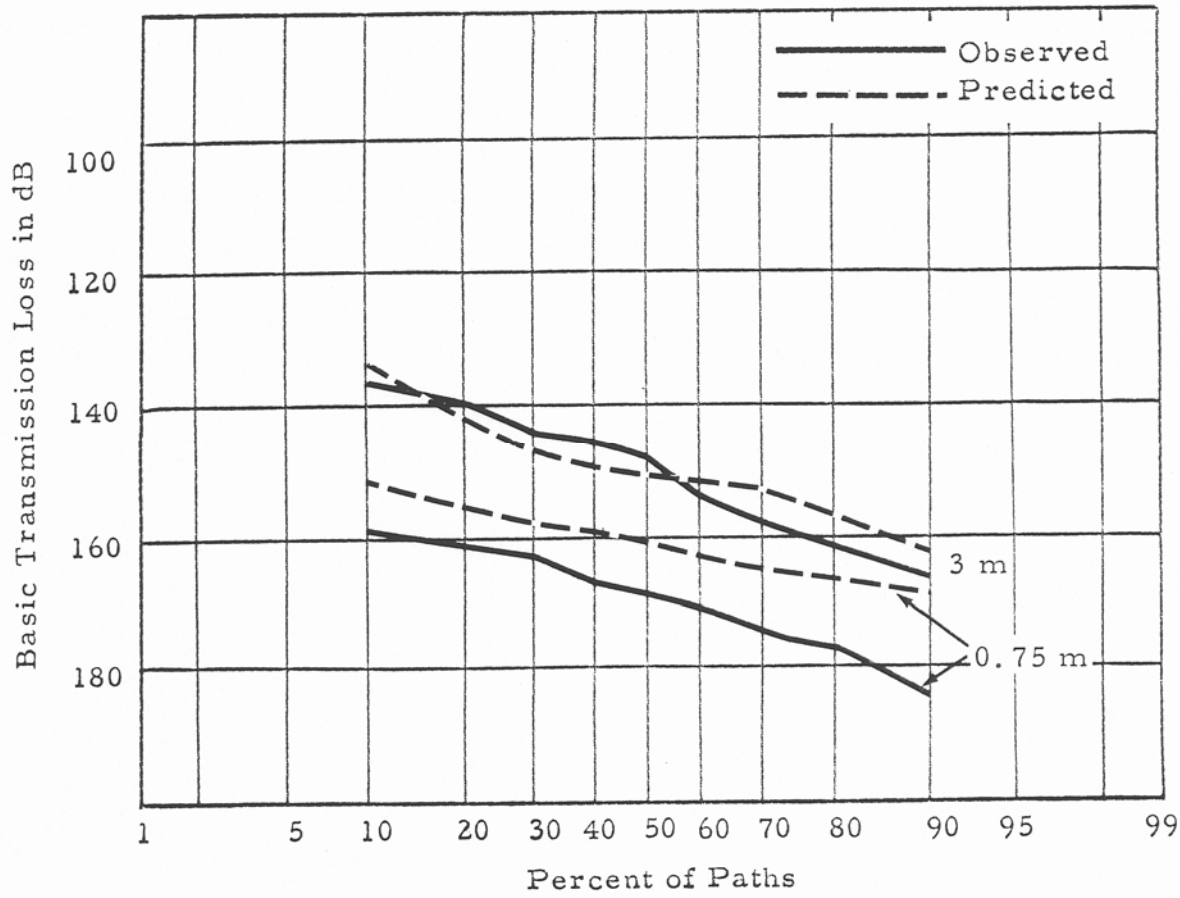


Figure 42. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Idaho, f=230 MHz.



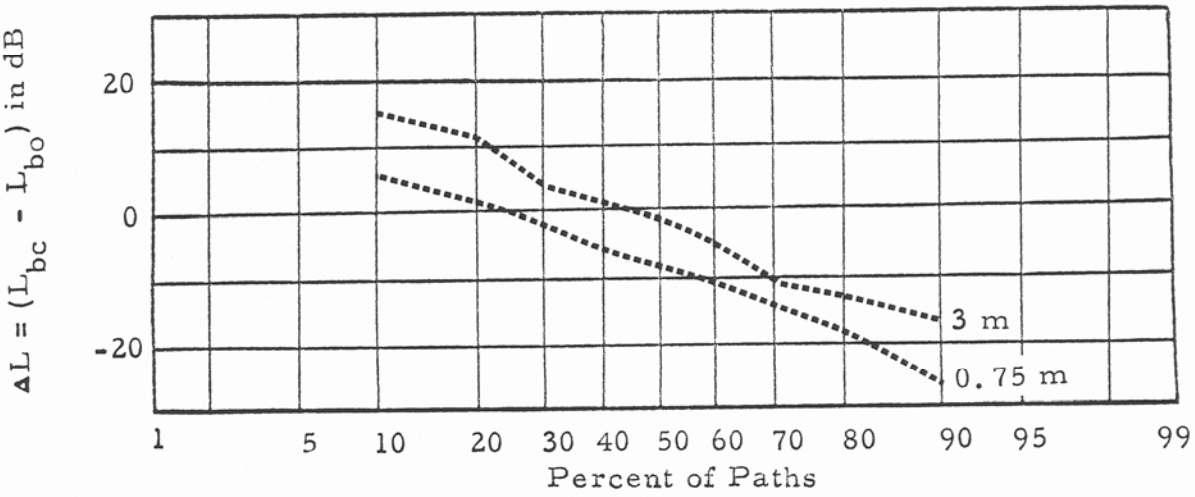


Figure 43. Cumulative distributions of basic transmission loss, observed and predicted, and of ΔL, Idaho, f=416 MHz.

Table 3. Cumulative Distributions of Path Parameters, Washington

Parameter	Percentage									
	Min	10	20	30	40	50	60	70	80	90
Ritzville, 15 paths, $h_{g1}=h_{g2}=0.75$ m										
d	9.4	9.9	11.4	18.6	19.8	22.3	22.8	23.7	29.6	49.0
Δh	19.6	29.1	44.2	65.4	67.6	70.0	78.8	80.3	139.0	195.0
d_{L1}	1.5	1.7	2.0	2.0	2.3	2.5	3.7	4.5	7.5	9.7
d_{L2}	0.2	0.2	0.9	1.7	3.3	6.4	7.6	9.5	12.9	14.1
d_L	1.7	2.6	6.4	9.9	10.2	11.2	11.8	12.6	14.9	16.4
θ_e	0.9	0.9	1.6	2.4	3.0	4.0	8.3	12.4	16.1	19.4
no line-of-sight, 3 1-horizon paths										
Rugged terrain, 53 paths, $h_{g1}=h_{g2}=0.75$ m										
d	1.4	3.2	9.0	12.6	17.5	22.6	24.5	26.8	31.9	37.3
Δh	2.3	85.4	128.2	178.7	193.4	257.5	321.4	378.3	424.6	500.0
d_{L1}	0.1	0.5	0.8	1.0	1.1	1.8	2.1	3.1	5.6	13.7
d_{L2}	0.1	0.2	0.6	1.2	2.0	3.4	8.1	12.0	15.8	20.5
d_L	0.9	1.7	2.3	3.6	5.4	8.7	12.2	17.3	22.4	29.0
θ_e	-2.1	5.0	11.4	15.2	32.6	42.0	50.8	58.5	70.2	157.4
1 line-of-sight, 15 1-horizon paths										