elevation angles are independent of path length, provided that the path length chosen is greater than the sum of the horizon distances.

Figure 2.13 shows cumulative distributions θ_{e1}, θ_{e2}, and θ_e for 101 random paths with $h_{g1,2} = 1$ m, and figures 2.14 and 2.15 show similar distributions for 216 paths in the plains and in the mountains, with $h_{g1,2} = 10$ m. As with the horizon distances, the median value of θ_e is always greater than the sum of the median values of θ_{e1} and θ_{e2}. Table 2.4 shows median values of θ_{e1}, θ_{e2} and θ_e for several antenna height combinations.

Estimates of the elevation angles were made using the expression (6a) given in the main body of this report,

$$\theta_{e1,2} = \frac{0.0005}{d_{Ls1,2}} \left[1.3 \left(\frac{d_{Ls1\ 2}}{d_{L1,2}} - 1 \right) \Delta h - 4\, h_{e1,2} \right] \text{ radians.} \quad (6a)$$

Table 2.5 shows median values of θ_{e1}, θ_{e2}, and θ_e calculated using this expression and actual values of d_{L1} and d_{L2} as read from the profiles. Since no consistent distance dependence is observed, median values of θ_e for each antenna height combination are compared with the calculated values. For the random and plains paths, the median estimates of θ_e are approximately equal to the median values given in Table 2.4. For the mountain paths the estimated values of θ_e are almost twice as large as those obtained directly from profiles.

Considering the situation where predictions are based solely on estimates of terrain characteristics, without actual profiles for individual paths, values of θ_{e1}, θ_{e2}, and θ_e were calculated using equation (6a)

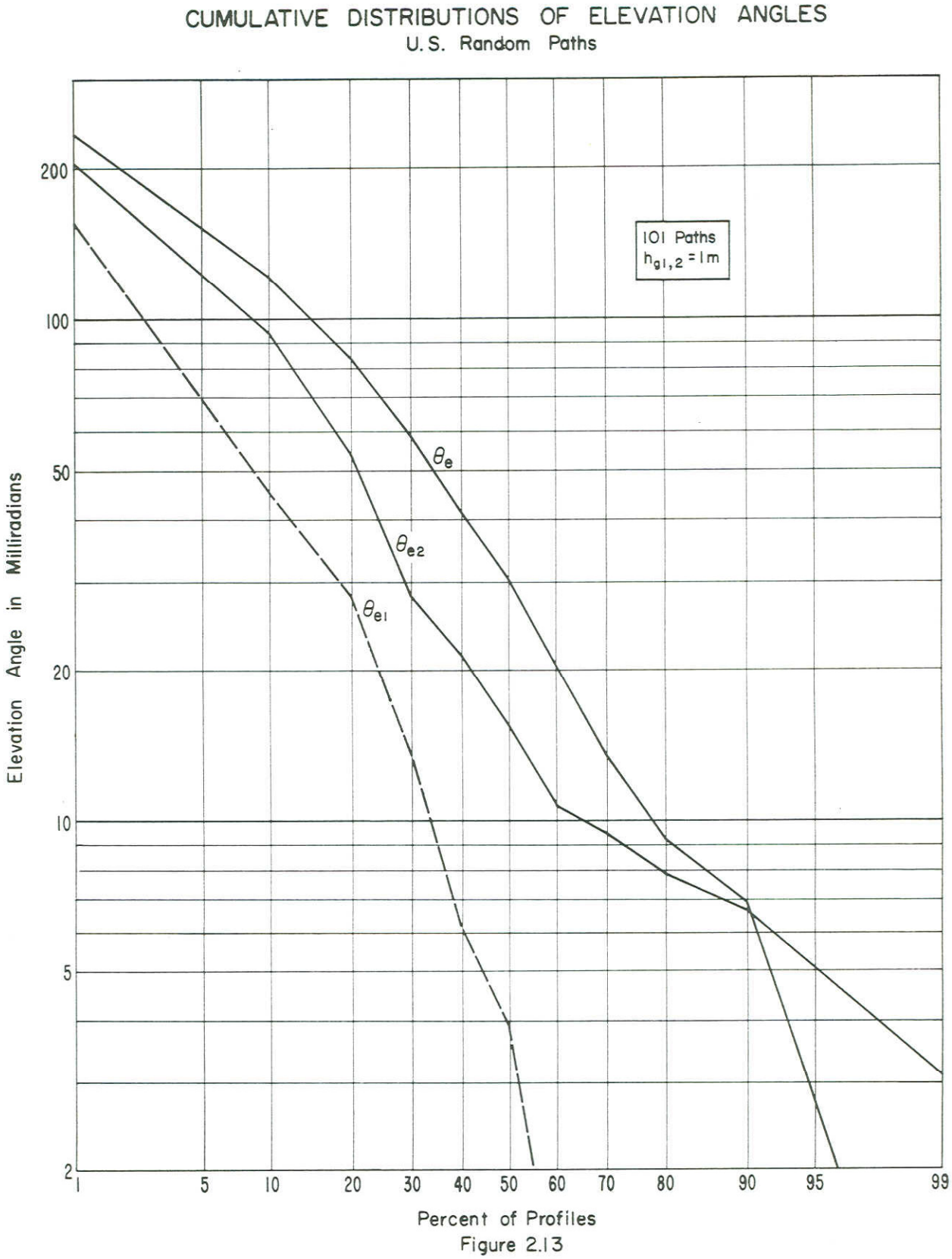
CUMULATIVE DISTRIBUTIONS OF ELEVATION ANGLES
U.S. Random Paths
101 Paths
$h_{g1,2}$ = 1m
θ_e
θ_{e2}
θ_{e1}
Elevation Angle in Milliradians
200
100
50
20
10
5
2
1
5
10
20
30
40
50
60
70
80
90
95
99
Percent of Profiles

Figure 2.13

CUMULATIVE DISTRIBUTIONS OF ELEVATION ANGLES
U.S. Plains Paths

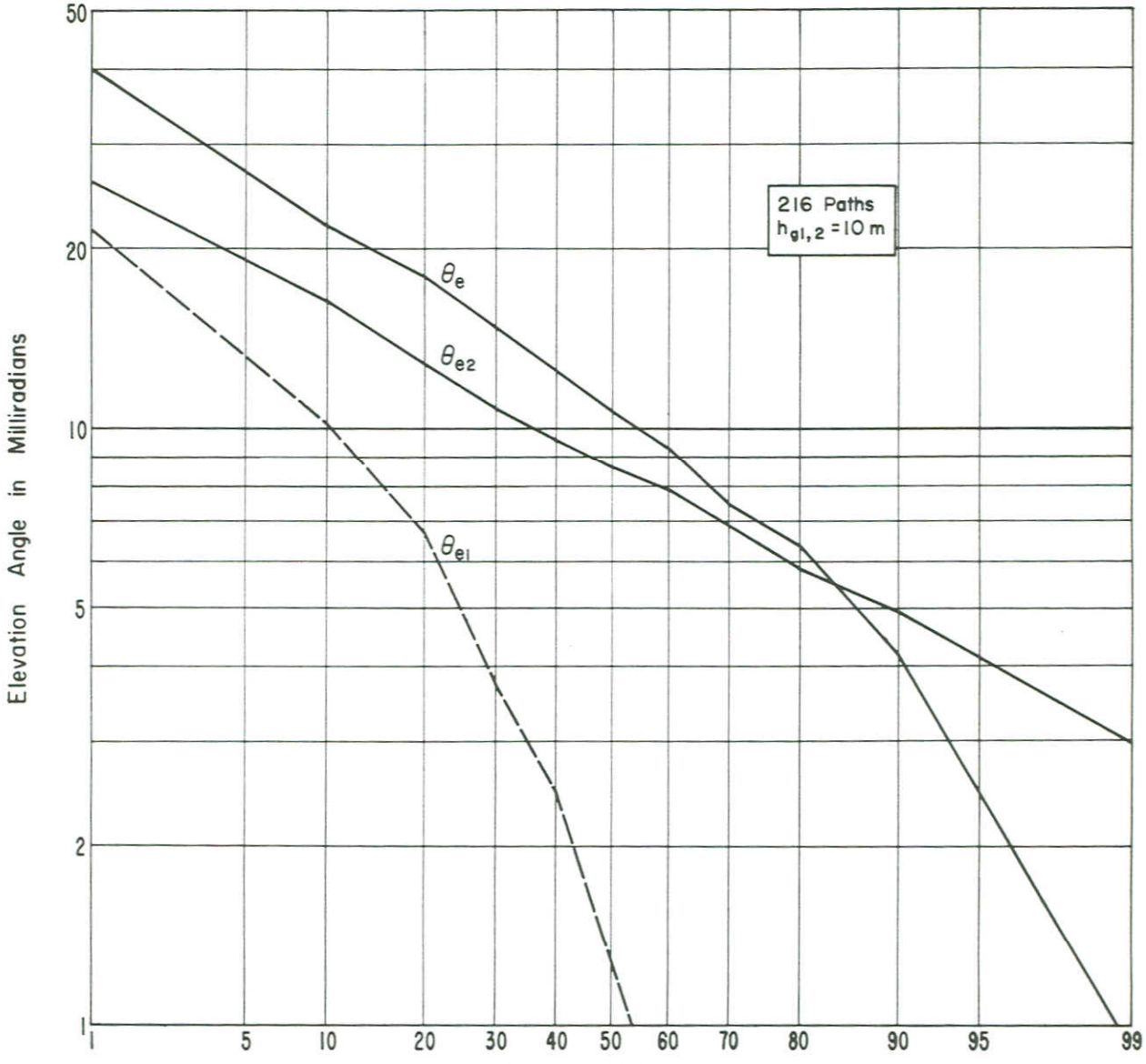

Figure 2.14

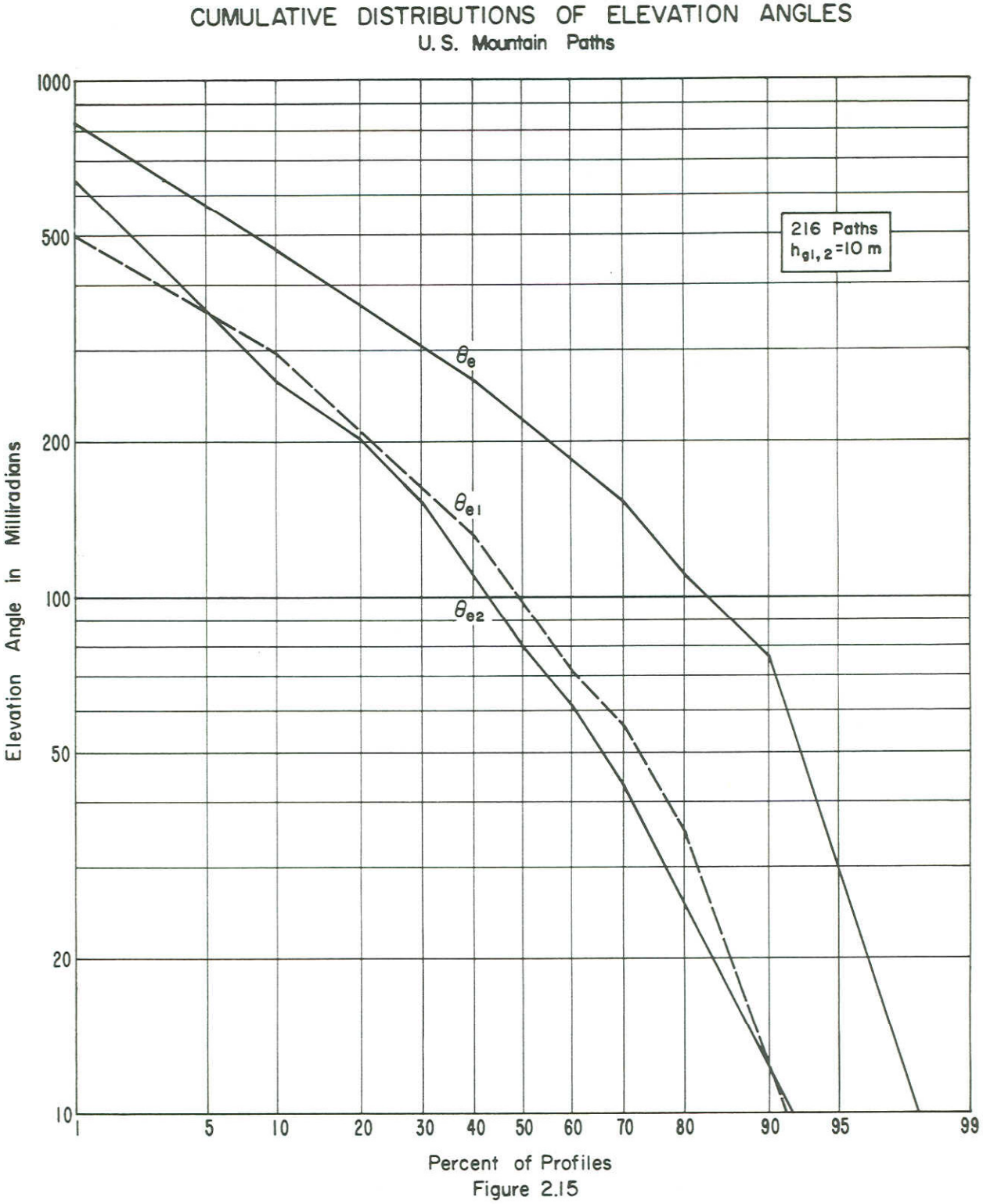
CUMULATIVE DISTRIBUTIONS OF ELEVATION ANGLES
U. S. Mountain Paths
216 Paths
$h_{g1,2}$=10 m
θ_e
θ_{e1}
θ_{e2}
Elevation Angle in Milliradians
1000
500
200
100
50
20
10
1
5
10
20
30
40
50
60
70
80
90
95
99
Percent of Profiles

Figure 2.15

Table 2.4

Median Values of the Elevation Angles

θ_{e1}, θ_{e2}, and θ_e in Milliradians

$h_{g1,2}$	1, 1			3, 3		m
d_{km}	θ_{e1}	θ_{e2}	θ_e	θ_{e1}	θ_{e2}	θ_e
Random						
30	2.95	10.72	19.73	2.59	9.33	17.63
40	3.84	12.64	25.10	2.85	11.00	21.38
50	3.98	13.11	22.52	3.25	12.78	19.34
60	3.96	15.36	30.38	3.30	13.71	29.73
Plains						
30	3.91	7.30	13.51	2.62	6.20	11.72
40	3.67	8.58	15.24	2.68	8.06	13.04
50	3.51	10.46	15.50	2.59	9.18	13.68
60	3.69	11.07	15.94	2.71	10.17	14.19
Mountains						
30	108.4	124.8	268.1	106.1	122.6	263.1
40	105.0	81.8	212.2	104.4	81.3	207.3
50	99.5	75.7	206.5	99.1	73.9	203.4
60	100.0	85.0	227.9	97.1	84.4	225.9

Table 2.4 (continued)

$h_{g1,2}$	3, 10			10, 10		m
d_{km}	θ_{e1}	θ_{e2}	θ_e	θ_{e1}	θ_{e2}	θ_e
Random						
30	2.68	6.92	15.04	1.59	7.26	13.22
40	3.42	7.54	20.04	1.67	7.70	19.72
50	3.28	10.53	16.44	1.83	10.86	14.79
60	3.40	11.26	25.22	1.33	11.26	23.16
Plains						
30	2.70	4.40	9.86	1.37	4.44	8.47
40	2.70	6.25	10.90	1.47	6.26	9.75
50	2.59	7.78	11.88	1.58	7.78	9.80
60	2.71	8.62	12.22	1.28	8.62	10.62
Mountains						
30	106.1	117.1	255.8	100.9	117.1	249.0
40	104.4	77.1	201.7	102.2	77.1	197.9
50	99.1	68.3	199.3	94.9	68.3	192.1
60	97.3	79.0	220.1	93.2	79.0	215.4

Table 2.5

Median Values of the Elevation Angles Calculated Using (6a), With d_{L1}, d_{L2} from Profiles

θ_{e1}, θ_{e2}, θ_e in milliradians

$h_{g1,2}$	1, 1			3, 3		m
d_{km}	θ_{e1}	θ_{e2}	θ_e	θ_{e1}	θ_{e2}	θ_e
Random						
30	0.11	8.88	24.17	0.81	7.78	25.46
40	0	14.73	33.71	0.06	10.56	25.63
50	0	4.98	33.36	0.06	5.69	23.79
60	-2.17	8.88	30.01	0.06	7.78	26.54
Plains						
30	1.15	0	11.51	1.51	1.51	10.10
40	1.15	-0.14	20.09	0.78	1.51	8.78
50	1.15	0	17.65	0.17	0.78	9.93
60	1.15	-1.41	14.28	0.17	0	9.65
Mountains						
30	46.8	241.8	678.6	108.9	303.9	754.0
40	46.8	85.8	359.6	108.9	147.9	479.6
50	46.8	85.8	418.6	108.9	147.9	510.2
60	46.8	144.3	581.1	108.9	206.4	705.2

Table 2.5 (continued)

$h_{g1,2}$	3, 10			10, 10		m
d_{km}	θ_{e1}	θ_{e2}	θ_e	θ_{e1}	θ_{e2}	θ_e
Random						
30	1.26	1.36	15.20	0.54	1.36	17.99
40	0.44	3.04	23.36	0.20	3.04	20.68
50	0.06	3.79	15.85	0	3.79	14.55
60	0.06	4.68	15.59	0	4.68	14.74
Plains						
30	1.96	0	5.96	0.37	0	4.47
40	0.78	0	4.99	0.07	0	2.68
50	0.17	-0.19	4.77	-0.19	-0.19	3.12
60	0.17	0.07	5.72	-0.19	0.07	2.03
Mountains						
30	108.9	244.2	651.1	118.8	244.2	618.4
40	108.9	146.7	504.7	118.8	146.7	526.8
50	108.9	146.7	495.6	118.8	146.7	520.9
60	108.9	146.7	580.6	118.8	146.7	544.1

with values of d_{L1} and d_{L2} calculated as functions of Δh (5c). As one would expect, these estimates of θ_e do not correspond closely to median values from individual profiles.

Table 2.6 shows the comparison between (a) median values of θ_e obtained directly from terrain profiles, (b) those estimated using actual horizon distances in (6a), and (c) values calculated using (6a) and estimates of d_{L1} and d_{L2} computed using (5c). For the random and plains

Table 2.6

Elevation Angles θ_e in Milliradians

$h_{g1,2}$	1, 1	3, 3	3, 10	10, 10
Random				
a)	23.8	20.5	18.2	17.2
b)	31.7	25.6	15.7	16.4
c)	8.7	3.9	1.5	-1.0
Plains				
a)	15.4	13.4	10.9	9.8
b)	16.0	9.8	5.4	2.9
c)	4.5	1.5	-0.2	-1.9
Mountains				
a)	220.0	218.6	210.9	206.6
b)	499.8	607.7	542.6	535.4
c)	459.2	264.0	174.4	84.8

a) median values of θ_e from profiles

b) median values of θ_e calculated using (6a) and values of d_{L1}, d_{L2} from profiles

c) values of θ_e calculated using (6a) with values of $d_{L1,2}$ calculated using (5c)