Joint Attenuation – Rain Rate Statistics

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Presented by

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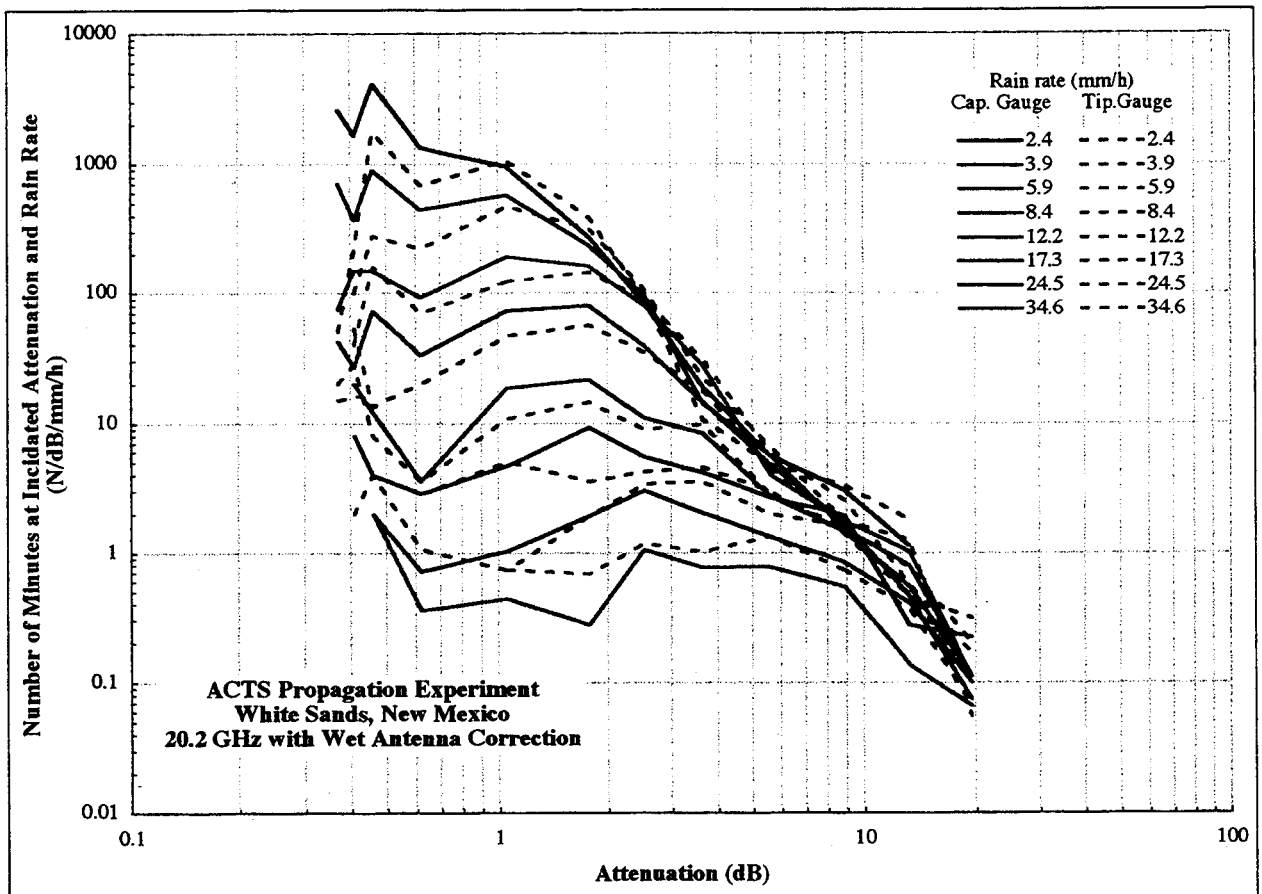
Ottawa, Canada

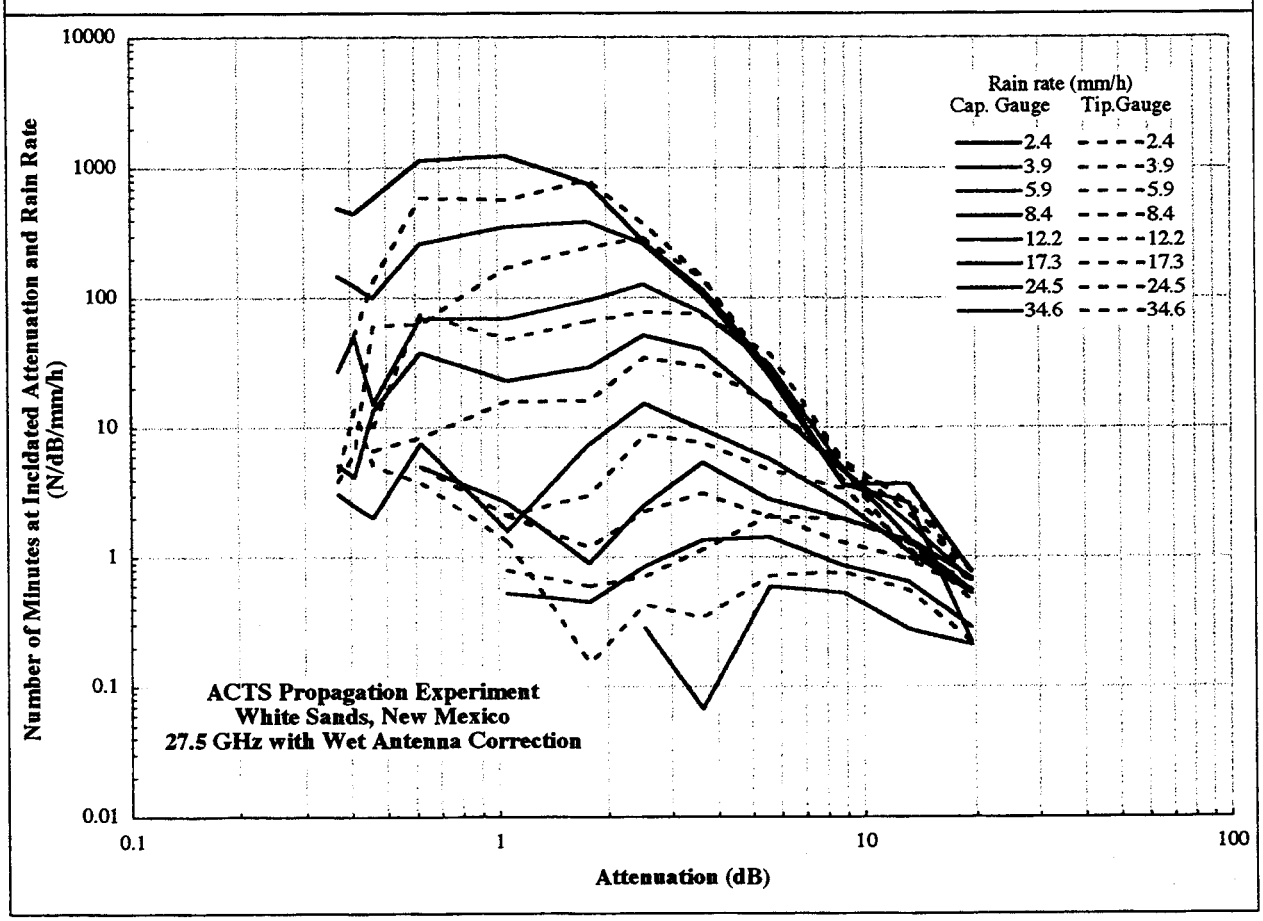
- Attenuation data from one minute averages generated by ACTSpp
- Wet antenna corrections made for plotting and averaging
- Rain rate data from each gauge processed by ACTSpp
- All observations entered in table including minutes marked bad for beacons and/or gauges
- Number densities scaled by bin widths
- Average attenuation conditioned on rain rate computed from the tables
- Model calculations made using the Crane Two-Component model using local rate data
- Local rain height for model calculations obtained form Oort - Rasmussen data base
- Expect measured attenuation to be greater than model predictions at low rates due to clouds
- Expect measured attenuation to be less than model predictions at high rates due to limited receiver dynamic range

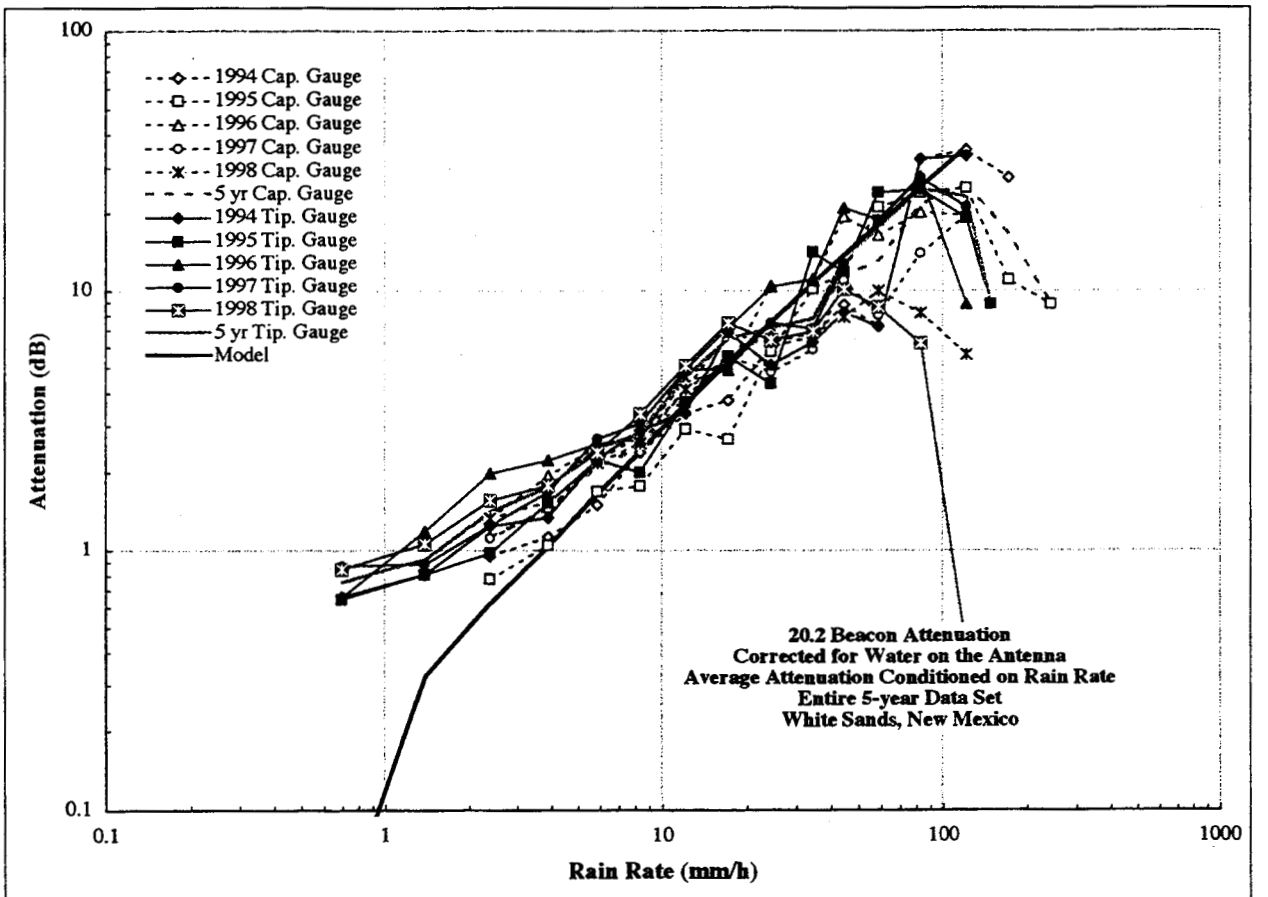
Joint Attenuation - Rain Rate Statistics - White Sands, New Mexico

Edge Wet corr. dB	C.Bin Wet corr. dB	RainRate Edge 0	mm/h 2 2.4	mm/h 3 3.9	mm/h 5 5.9	mm/h 7 8.4	mm/h 10 12.2	mm/h 15 17.3	mm/h 20 24.5	mm/h 30 34.6	mm/h 40 44.7	mm/h 50 59.2	mm/h 70 83.7	mm/h 100 122.5	mm/h 150 173.2	mm/h 200 244.9	mm/h 300 300	Mark Bad
		20.2 GHz Beacon Attenuation and Capacitor Gauge - minutes in each bin																
-0.5	0	1703058	1144	537	170	79	42	9	13	3	3		2	1	3			280097
0.35	0.37	312125	104	56	6	5												30017
0.39	0.41	117549	84	37	15	4	5	2										8856
0.44	0.46	26234	207	90	15	11	3	1	1	1		2						2795
0.49	0.62	7571	378	250	52	28	5	4	2	1								898
0.77	1.06	4888	654	792	262	149	63	16	7	3		1						442
1.45	1.78	1168	200	344	236	175	79	34	14	2	2	1						159
2.18	2.53	485	63	148	122	89	42	21	23	8	2	1						67
2.94	3.64	558	30	45	87	69	66	33	32	12	11	6	4	1				89
4.51	5.61	237	14	28	20	36	34	33	33	19	16	14	4	2				71
6.97	8.83	116	13	13	15	22	31	41	36	23	20	16	10	2	2	1		27
11.19	13.2	51	5	7	9	6	12	6	18	6	8	14	3	3	2			27
15.56	19.55	24		2	2	2	5	10	9	6	5	7	8	2	1			13
24.58	35	24					2		3	2	9	11	23	16	1			28
Mark	Bad	32987	68	40	17	11	8		1				9	19	2			5457

5 Years of Data


Number of Minutes at Incldated Attenuation and Rain Rate (N/dB/mm/h)
10000
1000
100
10
1
0.1
0.01
0.1
1
10
100
Attenuation (dB)
Rain rate (mm/h)
Cap. Gauge Tip.Gauge
2.4 2.4
3.9 3.9
5.9 5.9
8.4 8.4
12.2 12.2
17.3 17.3
24.5 24.5
34.6 34.6
ACTS Propagation Experiment
White Sands, New Mexico
20.2 GHz with Wet Antenna Correction


Number of Minutes at Incldated Attenuation and Rain Rate (N/dB/mm/h)
10000
1000
100
10
1
0.1
0.01
0.1
1
10
100
Attenuation (dB)
Rain rate (mm/h)
Cap. Gauge Tip.Gauge
2.4 2.4
3.9 3.9
5.9 5.9
8.4 8.4
12.2 12.2
17.3 17.3
24.5 24.5
34.6 34.6
ACTS Propagation Experiment
White Sands, New Mexico
27.5 GHz with Wet Antenna Correction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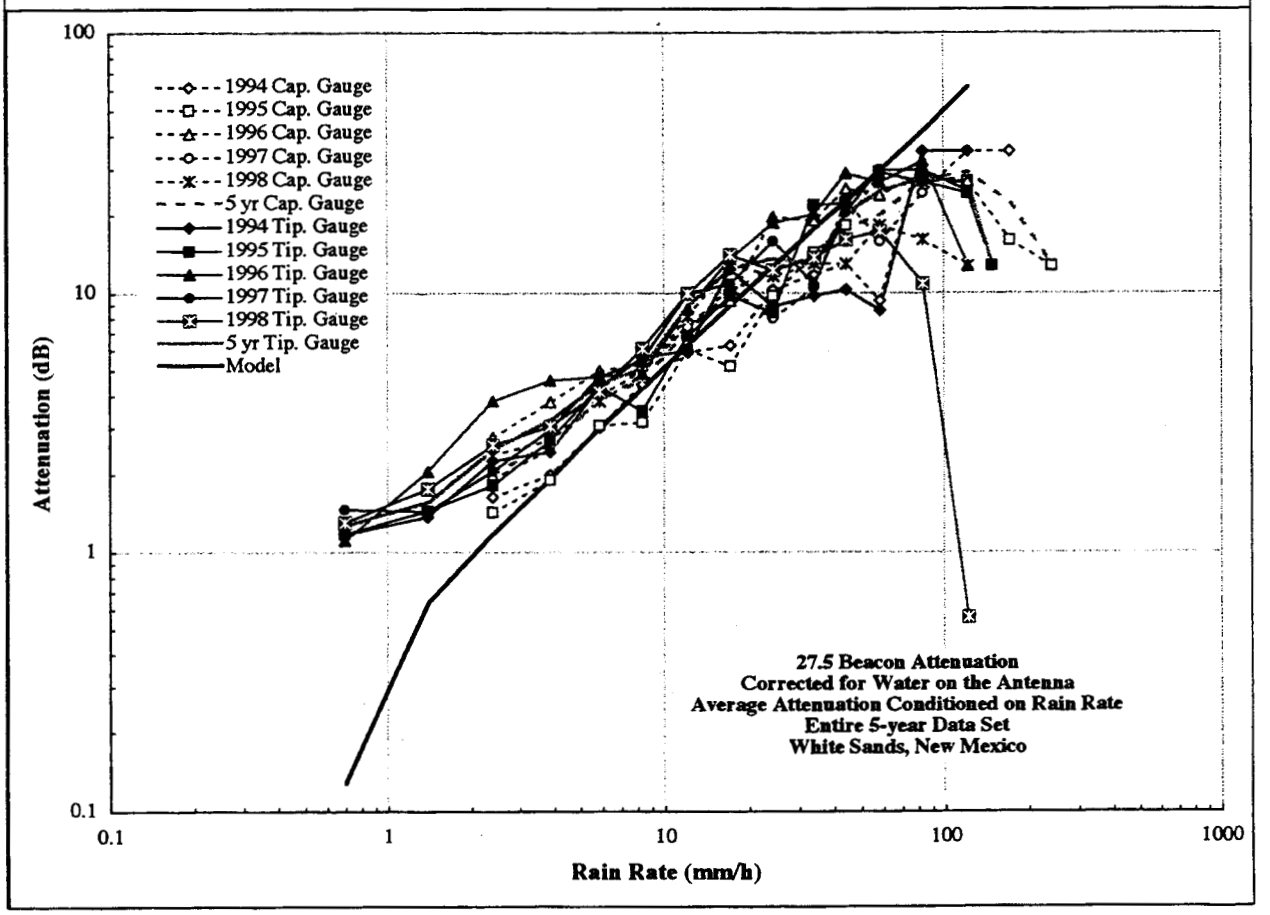
1995 Cap. Gauge
1996 Cap. Gauge
1997 Cap. Gauge
1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
20.2 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
White Sands, New Mexico
Attenuation (dB)
Rain Rate (mm/h)
100
10
1
0.1
0.1
1
10
100
1000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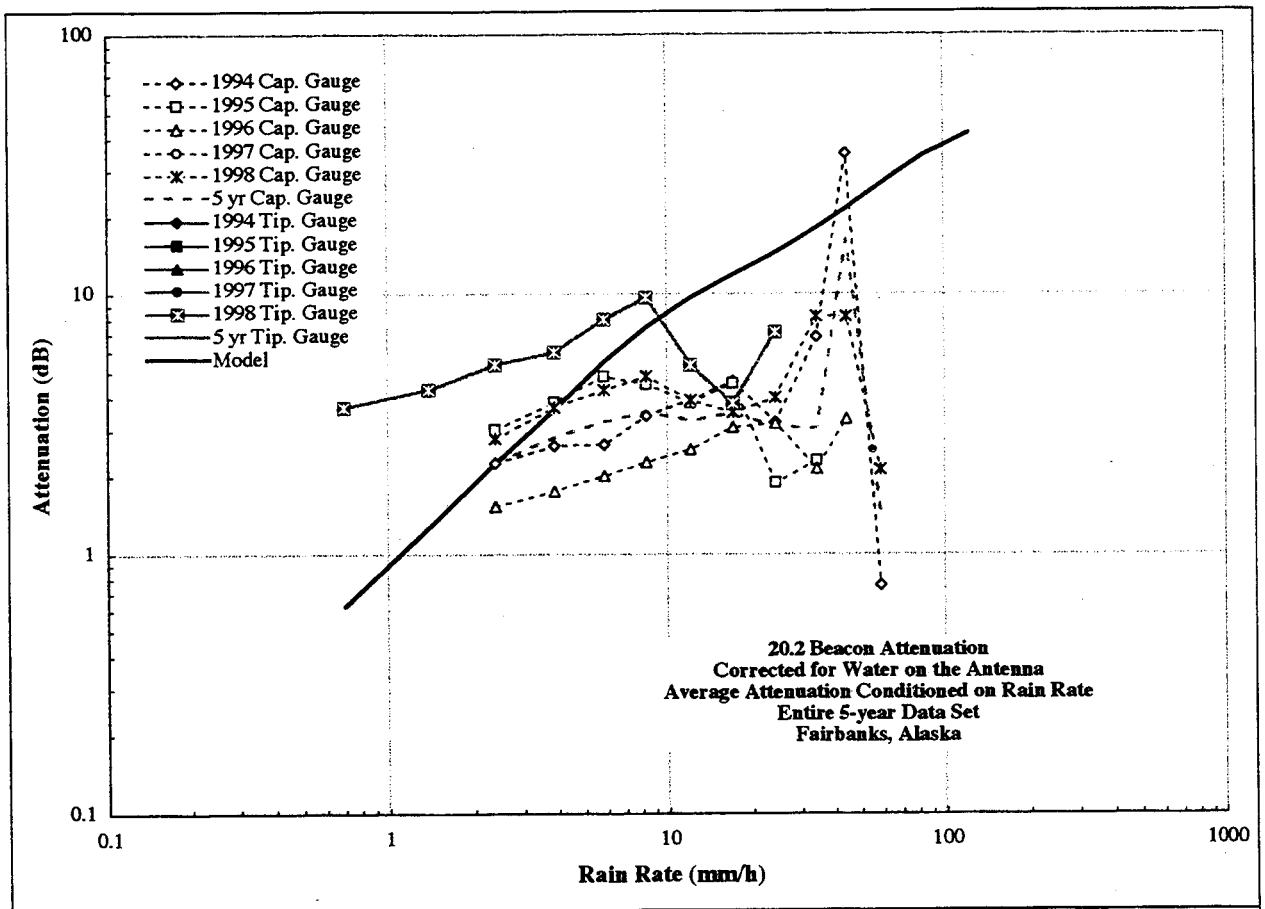
1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
27.5 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
White Sands, New Mexico
Attenuation (dB)
Rain Rate (mm/h)
100
10
1
0.1
0.1
1
10
100
1000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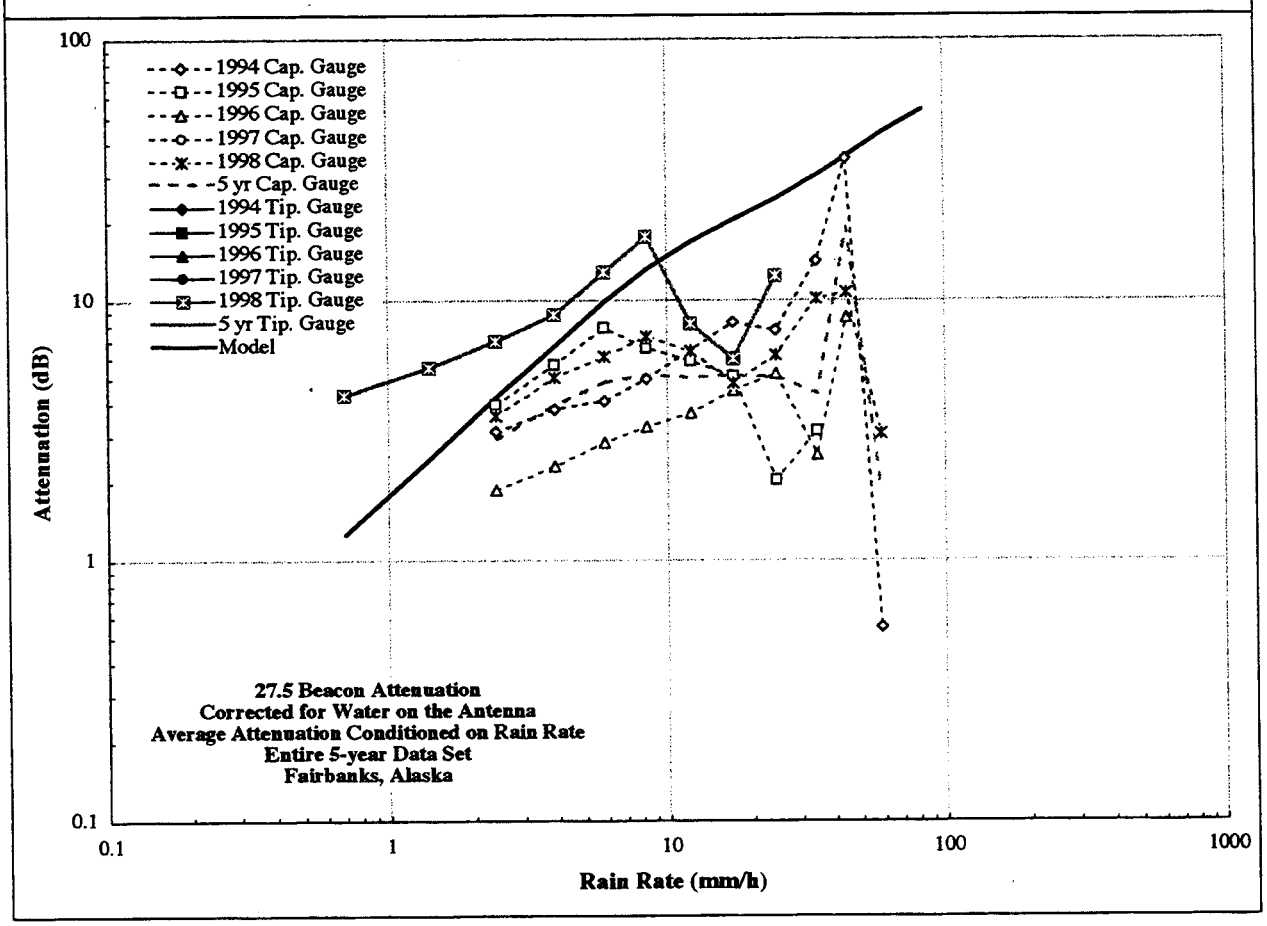
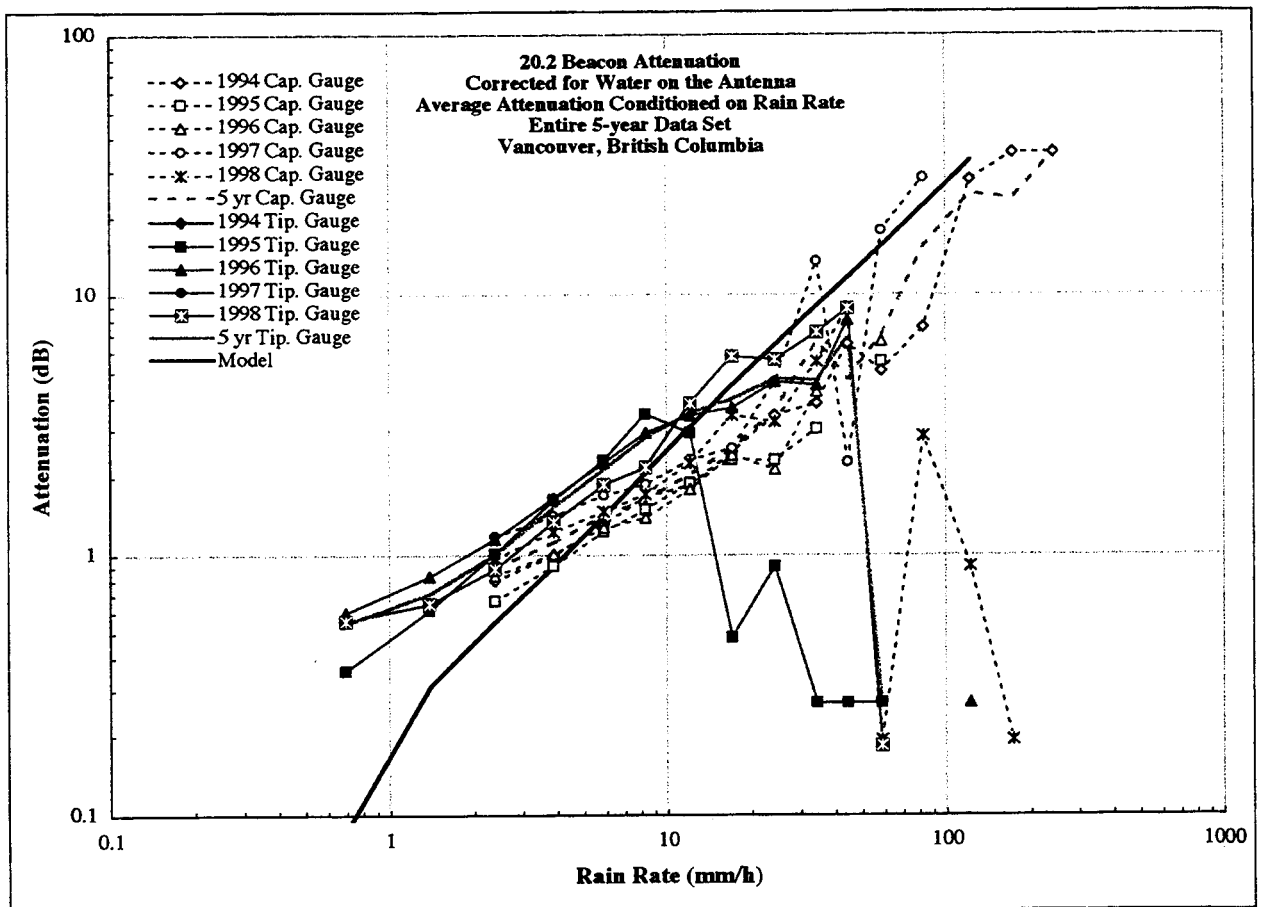
10
1
0.1
0.1
1
10
100
1000
Attenuation (dB)
Rain Rate (mm/h)
1994 Cap. Gauge
1995 Cap. Gauge
1996 Cap. Gauge
1997 Cap. Gauge
1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
20.2 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Fairbanks, Alaska


100
10
1
0.1
0.1
1
10
100
1000
Attenuation (dB)
Rain Rate (mm/h)
1994 Cap. Gauge
1995 Cap. Gauge
1996 Cap. Gauge
1997 Cap. Gauge
1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
27.5 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Fairbanks, Alaska


20.2 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Vancouver, British Columbia
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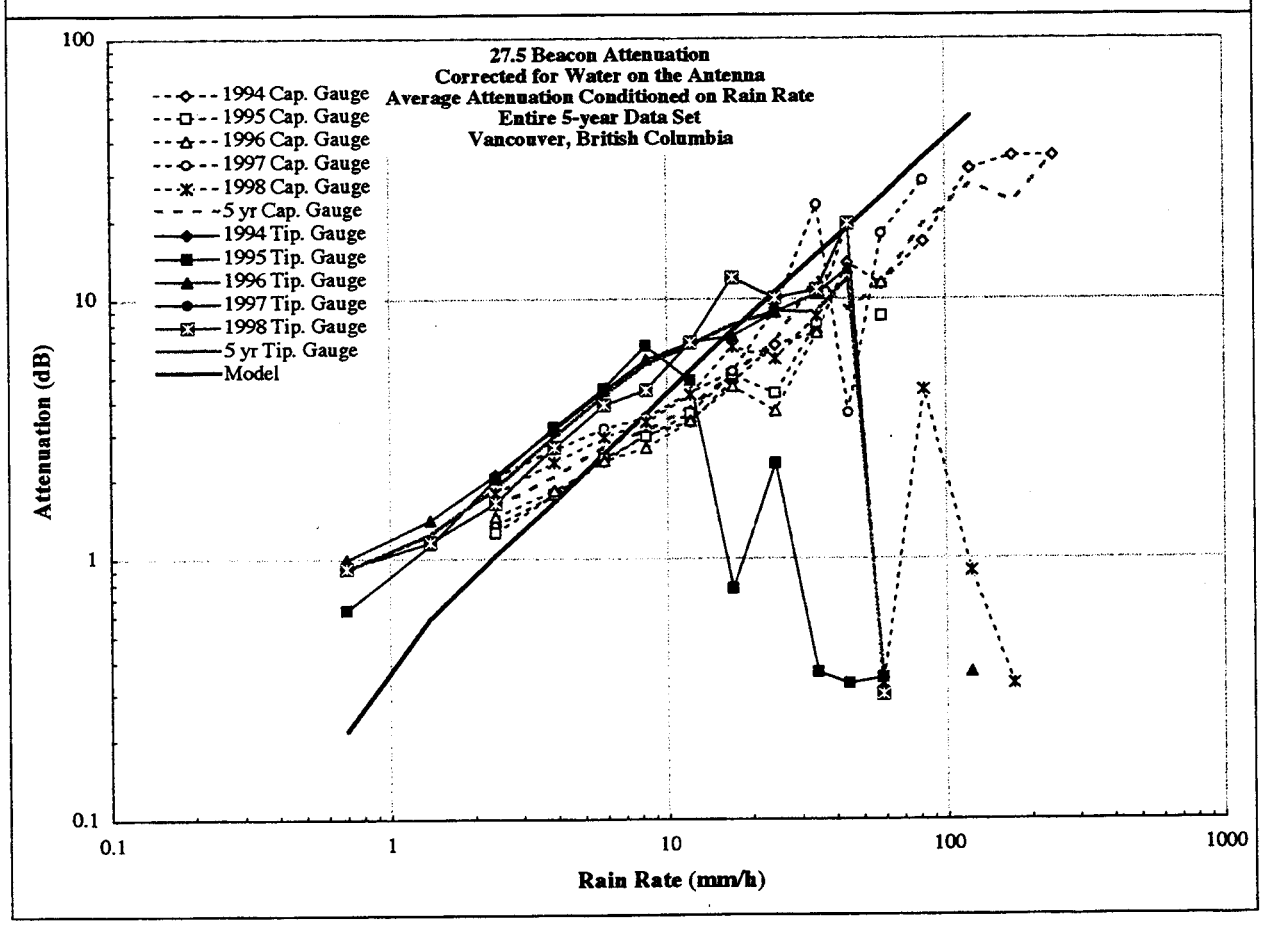
1995 Cap. Gauge
1996 Cap. Gauge
1997 Cap. Gauge
1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
Attenuation (dB)
Rain Rate (mm/h)
100
10
1
0.1
0.1
1
10
100
1000


27.5 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Vancouver, British Columbia
1994 Cap. Gauge
1995 Cap. Gauge
1996 Cap. Gauge
1997 Cap. Gauge
1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
Attenuation (dB)
Rain Rate (mm/h)
100
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0.1
0.1
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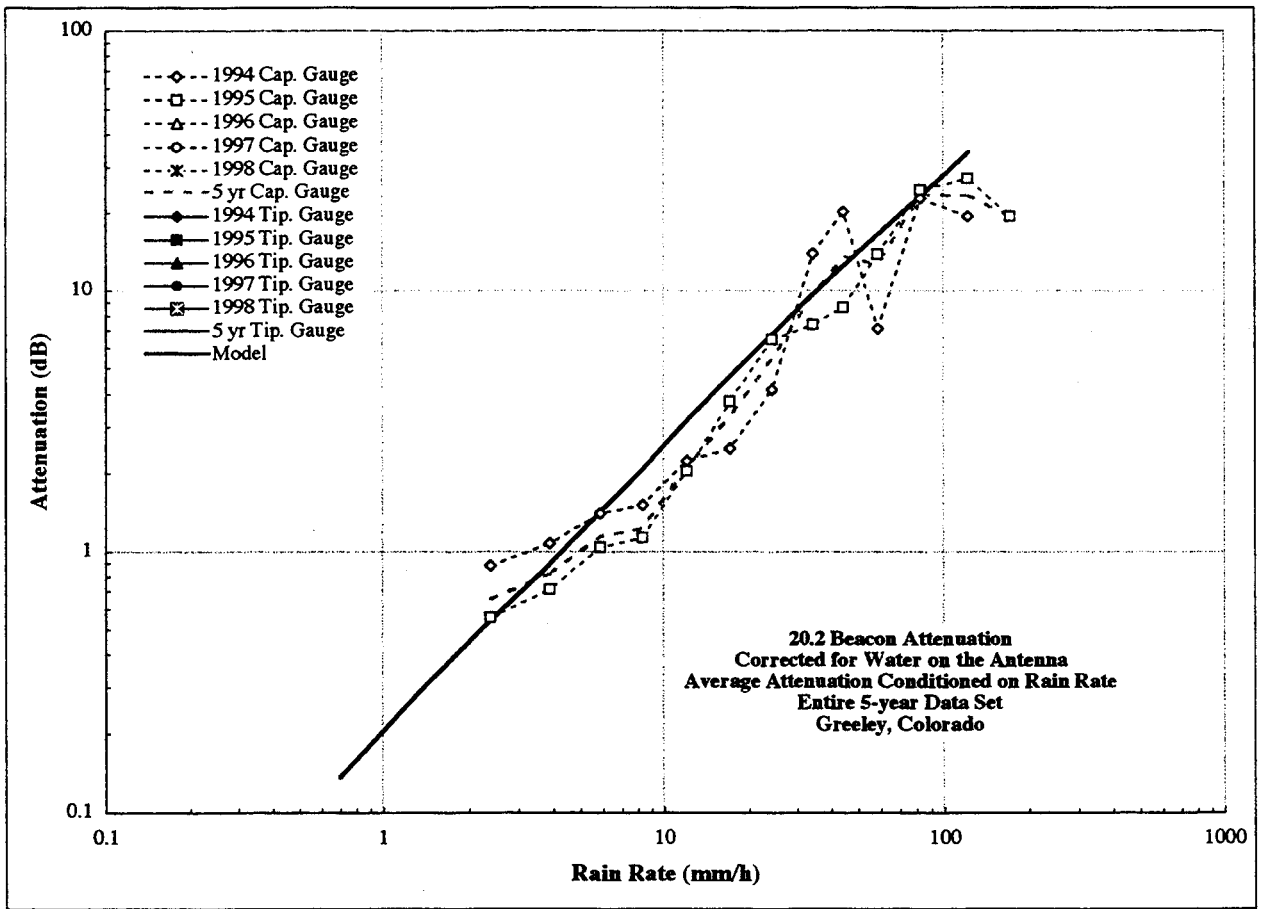
100
1000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Attenuation (dB)
Rain Rate (mm/h)
1994 Cap. Gauge
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1998 Cap. Gauge
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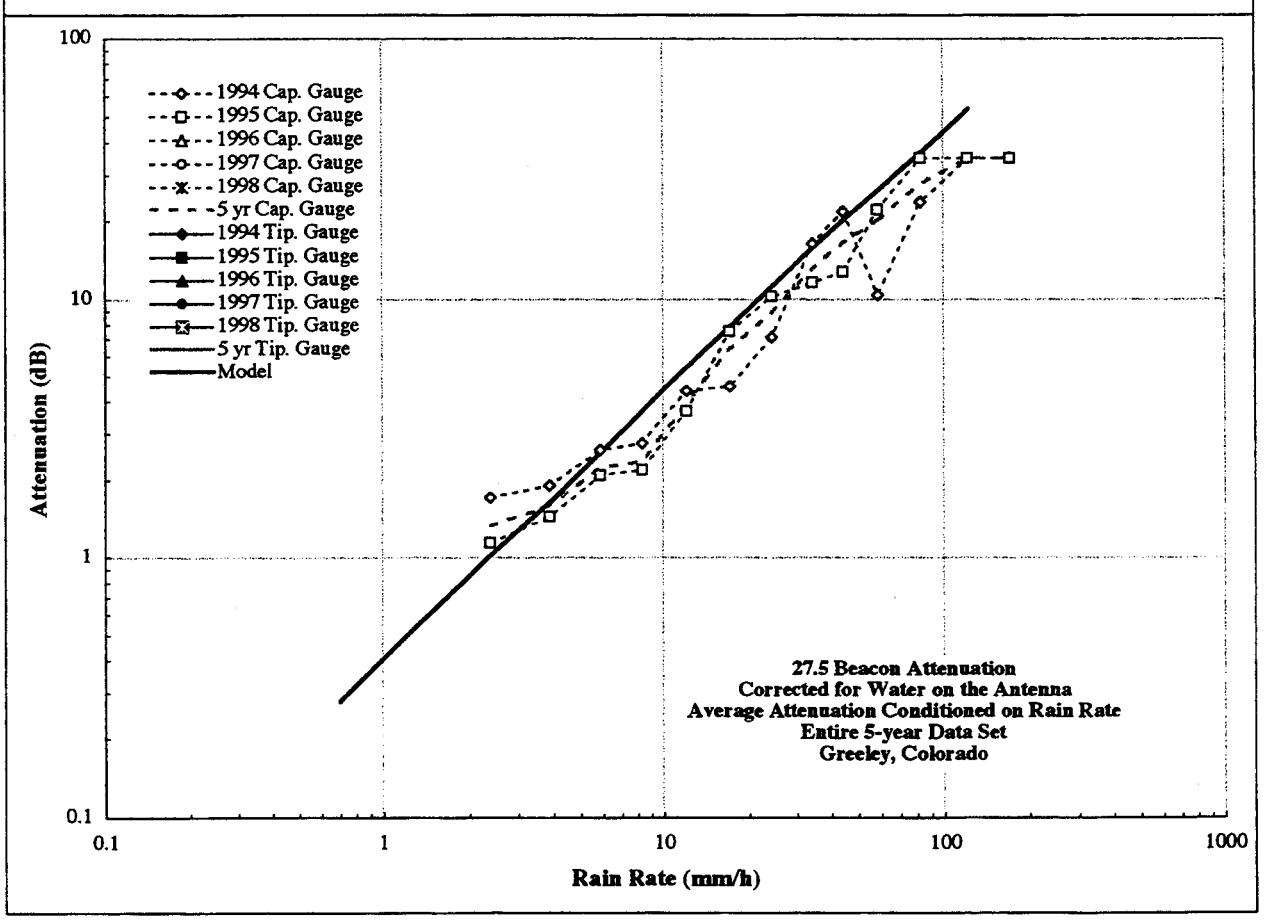
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
20.2 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Greeley, Colorado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100
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Attenuation (dB)
Rain Rate (mm/h)
1994 Cap. Gauge
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1997 Cap. Gauge
1998 Cap. Gauge
5 yr Cap. Gauge
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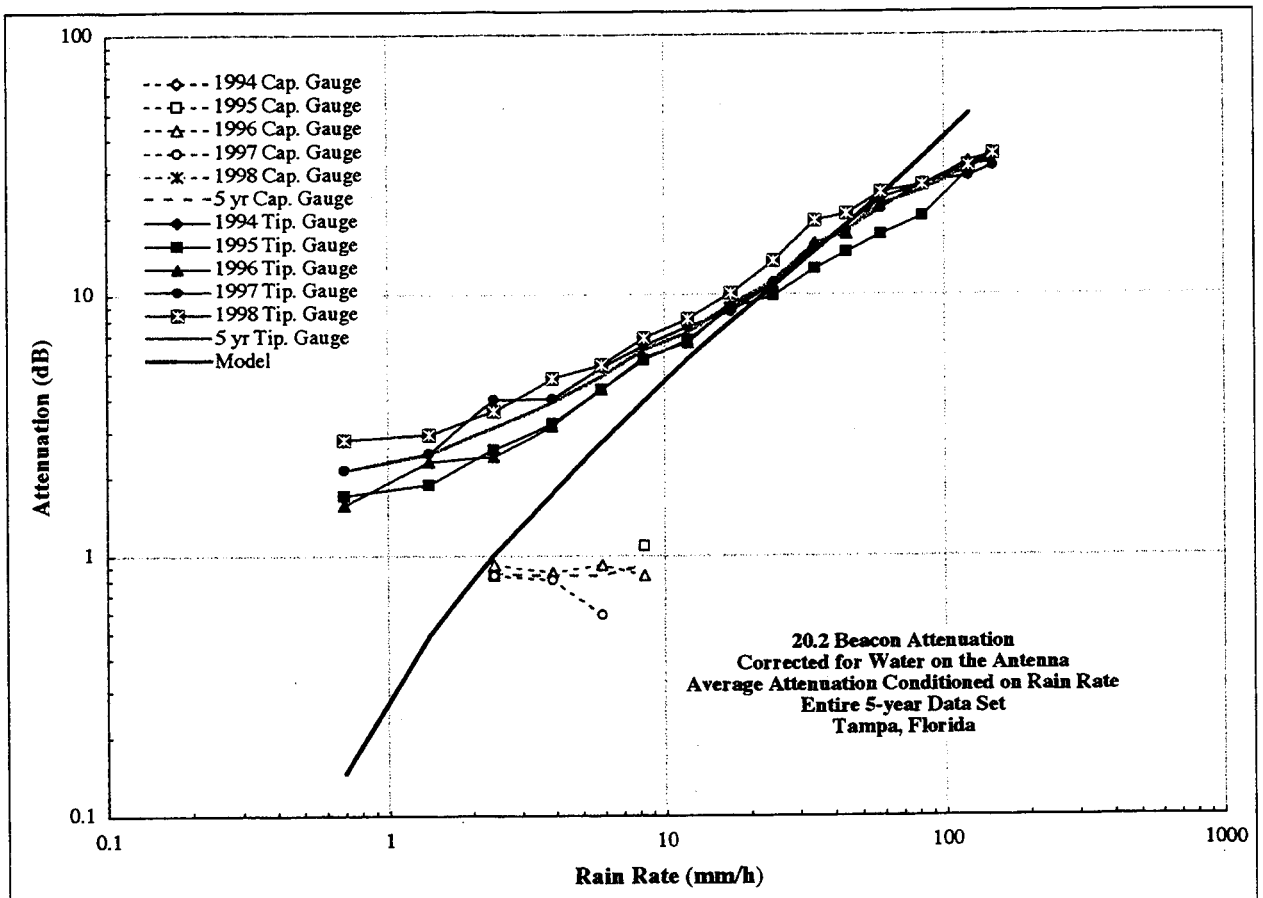
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
27.5 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Greeley, Colorado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1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
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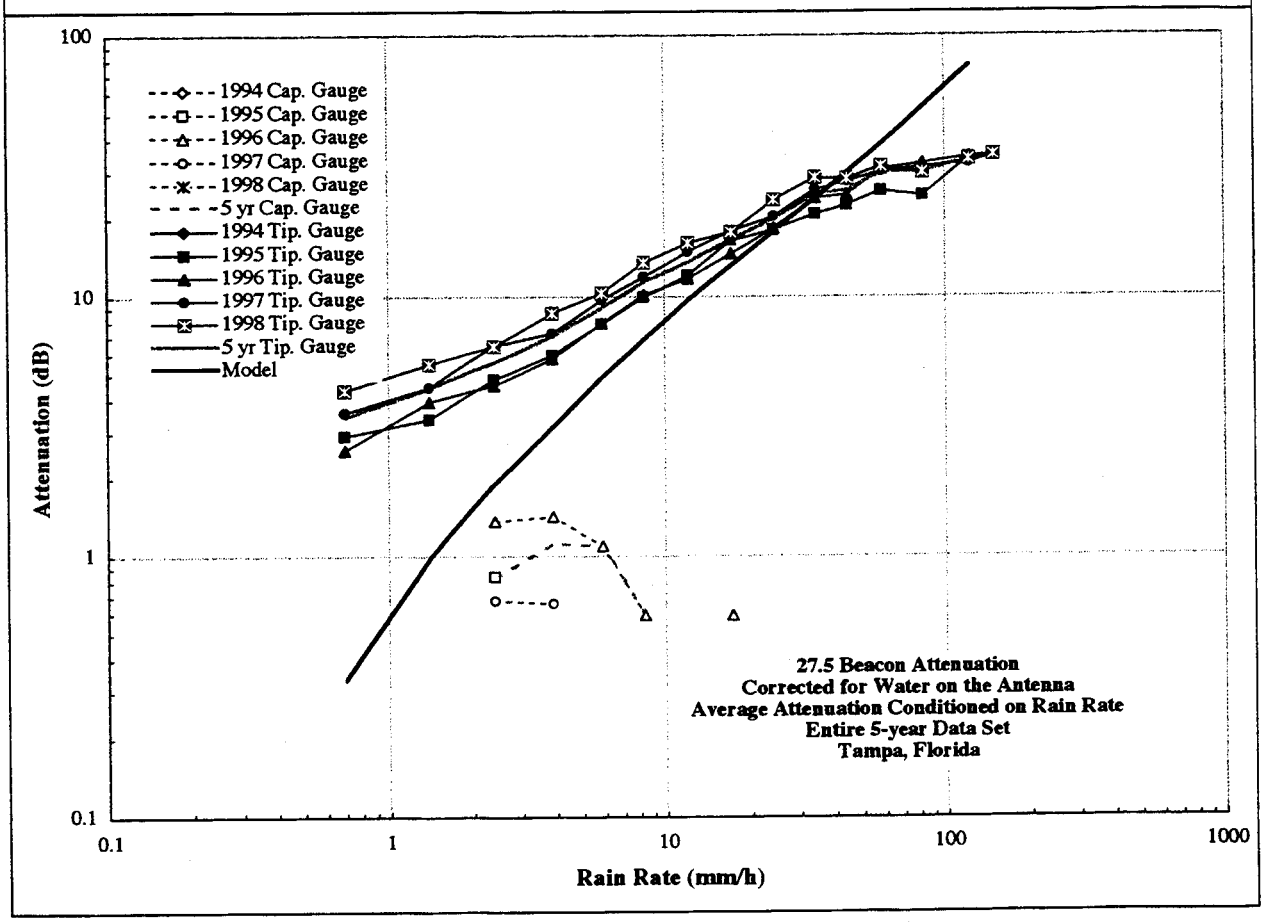
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
20.2 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Tampa, Florida
Attenuation (dB)
Rain Rate (mm/h)
100
10
1
0.1
0.1
1
10
100
1000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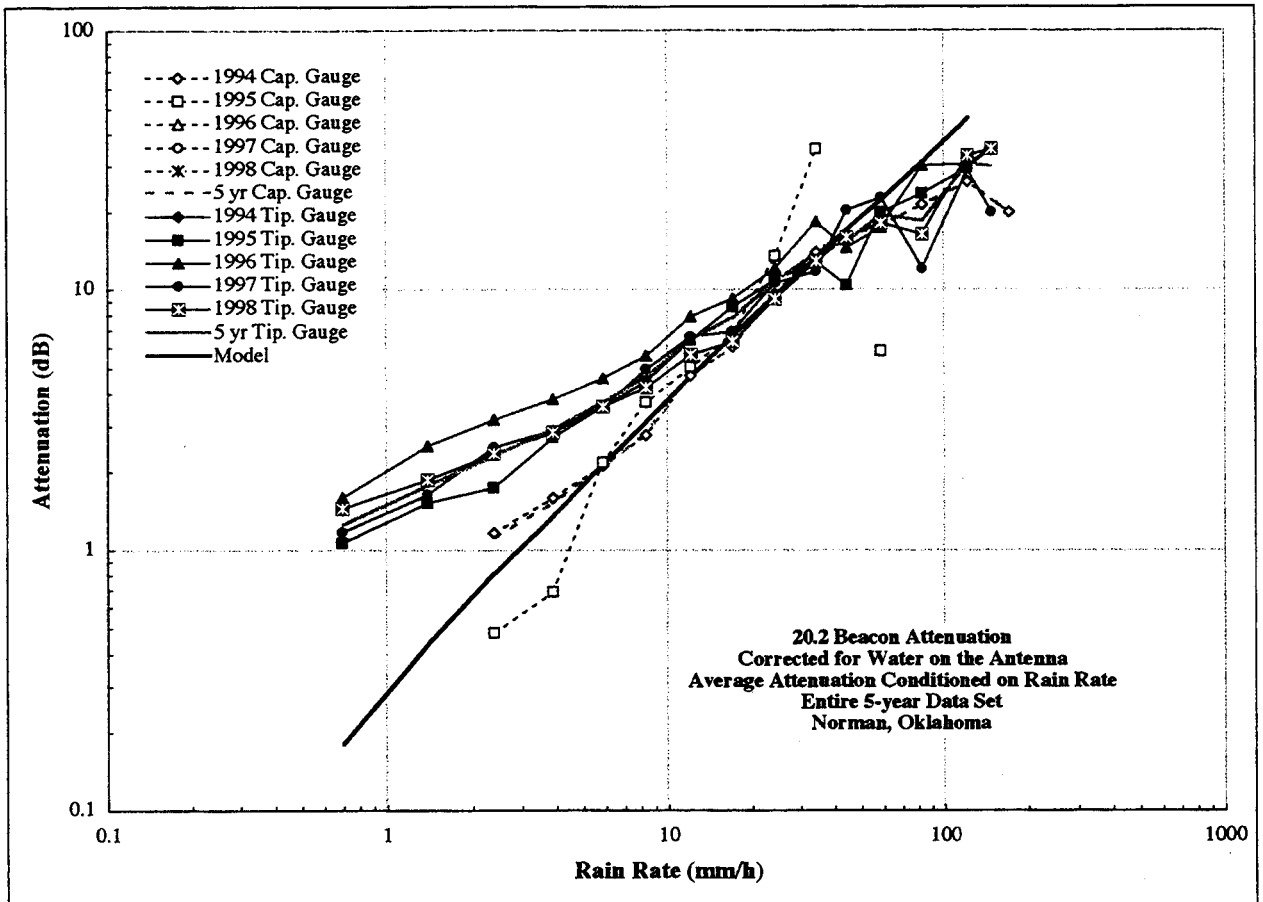
1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
27.5 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Tampa, Florida
Attenuation (dB)
Rain Rate (mm/h)
100
10
1
0.1
0.1
1
10
100
1000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1998 Cap. Gauge
5 yr Cap. Gauge
1994 Tip. Gauge
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1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
20.2 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Norman, Oklahoma
Attenuation (dB)
Rain Rate (mm/h)
100
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1
0.1
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100
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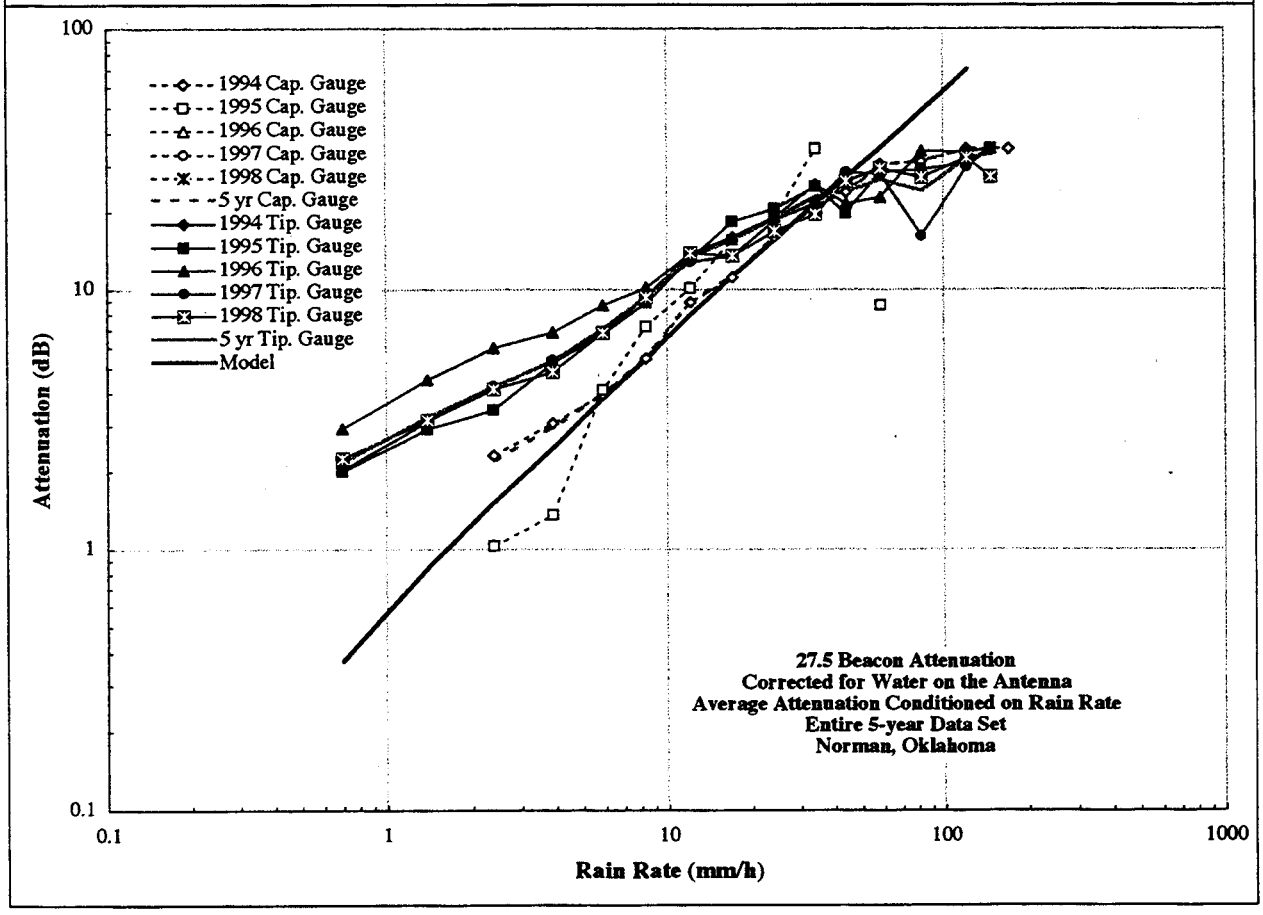
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Model
27.5 Beacon Attenuation
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Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Norman, Oklahoma
Attenuation (dB)
Rain Rate (mm/h)
100
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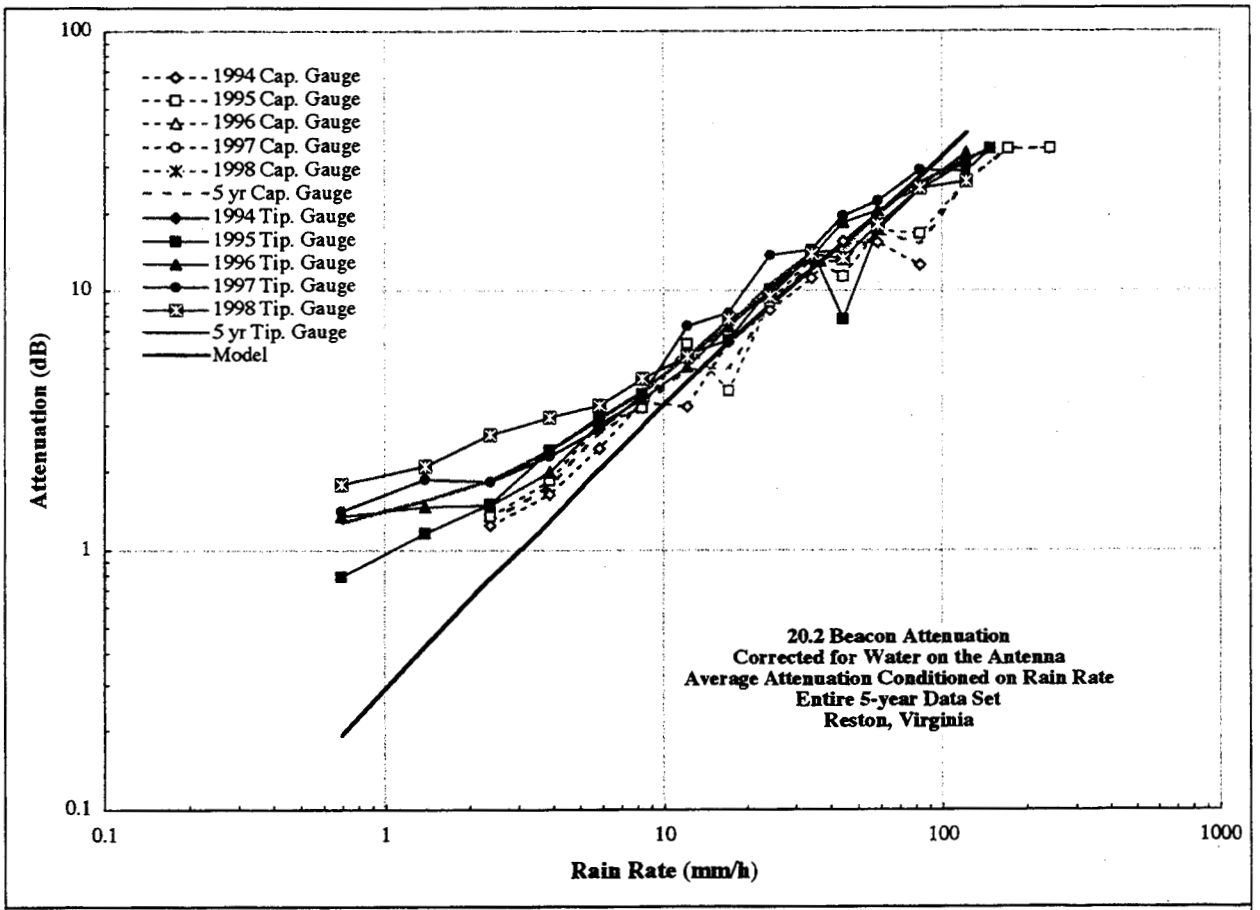
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Attenuation (dB)
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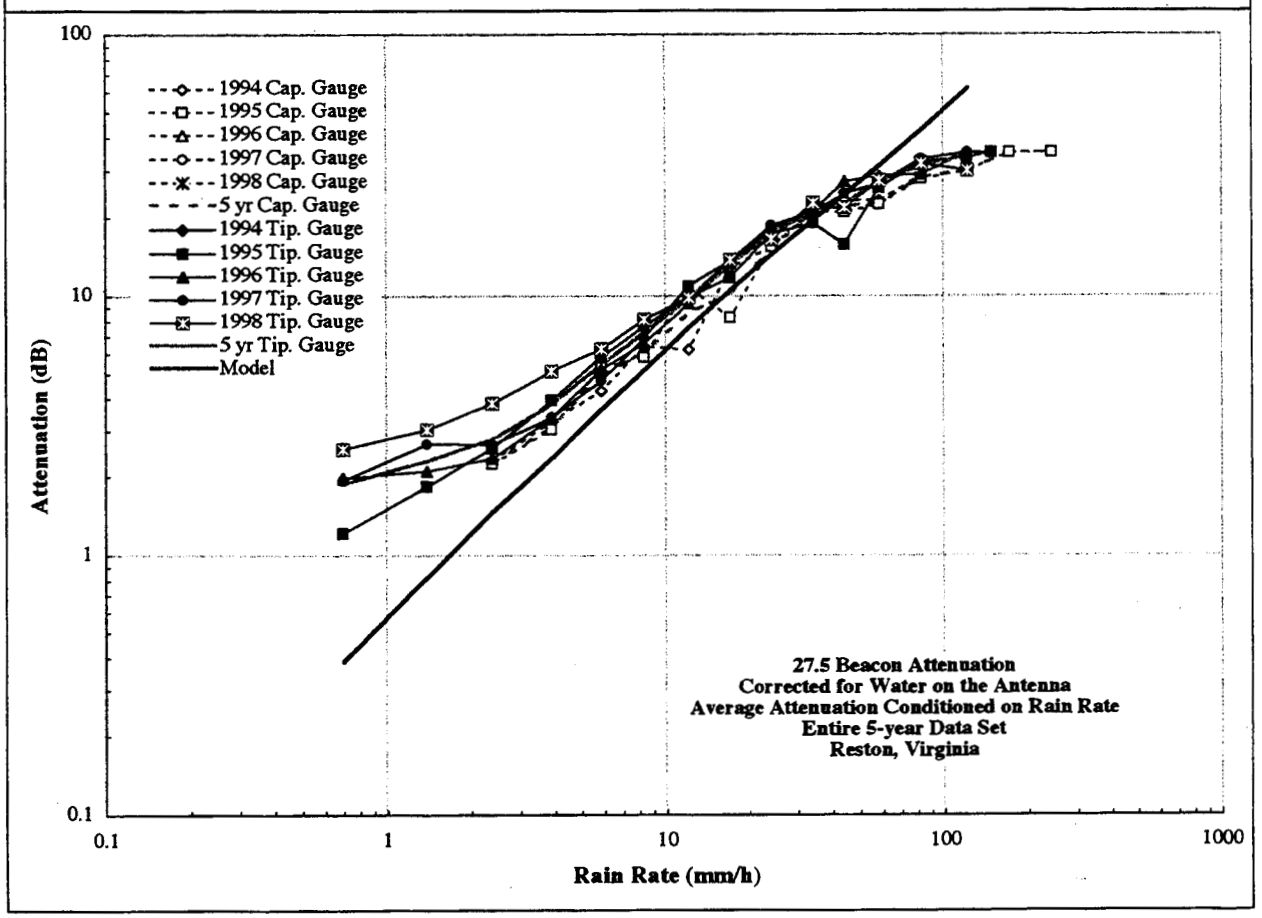
1998 Tip. Gauge
5 yr Tip. Gauge
Model
20.2 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Reston, Virginia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Attenuation (dB)
Rain Rate (mm/h)
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1997 Cap. Gauge
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5 yr Cap. Gauge
1994 Tip. Gauge
1995 Tip. Gauge
1996 Tip. Gauge
1997 Tip. Gauge
1998 Tip. Gauge
5 yr Tip. Gauge
Model
27.5 Beacon Attenuation
Corrected for Water on the Antenna
Average Attenuation Conditioned on Rain Rate
Entire 5-year Data Set
Reston, Virginia

Conclusions

- Observations and models agree for all sites but Alaska when the capacitor gauge is used
- Agreement implies the wet antenna correction model was valid
- Comparison between ACTS and COMSTAR observations for Virginia and Florida also shows the wet antenna correction model was valid
- A detailed year-by-year analysis shows a progressive increase in attenuation due to water on the antenna reflector and feed with time
- For all sites, the wet antenna correction was too large for the first year by approximately the amount of attenuation produced by water on the feed window