Stanford Telecom / New Mexico State University

ACTS PROPAGATION MEASUREMENTS PROGRAM

Data Analysis Summary

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NAPEX XIX and APSW VII
June 14-16, 1995

Fort Collins, Colorado

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TOPICS

- INTRODUCTION
  - EXPERIMENT OBJECTIVES
  - EXPERIMENT CONFIGURATION
- ACTS K_A BAND MEASUREMENTS SUMMARY
  - SAMPLE MONTHLY ATTENUATION AND WEATHER MEASUREMENTS
  - ANNUAL CY94 STATISTICS
  - FADE DURATION STATISTICS
  - STATUS OF *.PV1 PROCESSING
- APPLICATION OF ACTS MEASUREMENTS TO TDRS SGL'S
  - FREQUENCY SCALING AND ELEVATION ANGLE SCALING
  - PEAK ATTENUATION RATIO MEASUREMENTS
  - CY94 ATTENUATION STATISTICS SUMMARY
  - TDRS SGL PERFORMANCE STATISTICS SUMMARY
- FUTURE ACTIVITIES

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STel ACTS PROPAGATION EXPERIMENT OBJECTIVES

- MEASURE AND EVALUATE Ka-BAND PROPAGATION EFFECTS AND LINK PERFORMANCE AT LAS CRUCES, NM UTILIZING AN ACTS PROPAGATION TERMINAL (APT)
- DEVELOP LONG-TERM STATISTICS AND PREDICTION MODELING TECHNIQUES FOR LAS CRUCES CLIMATE REGION FOR APPLICATION TO ADVANCED SYSTEM PLANNING AND DESIGN
- APPLY ACTS MEASUREMENTS (20.185 GHz AND 27.5 GHz) TO THE EVALUATION OF CURRENT AND PLANNED TDRS SPACE-TO-GROUND LINK (SGL) PERFORMANCE

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STel ACTS PROPAGATION EXPERIMENT MEASUREMENTS

- ACTS PROPAGATION TERMINAL (APT), COLOCATED AT STGT
  - ELEVATION ANGLE TO ACTS: 51°
  - MEASURED PARAMETERS
    - 20.185 GHGz BEACON
    - 27.5 GHz BEACON
    - 20 GHx RADIOMETER
    - 27 GHz RADIOMETER
    - RAIN RATE (CRG, TBG)
    - TEMPERATURE, RELATIVE HUMIDITY, WATER VAPOR DENSITY, WIND VECTOR
- ANCILLARY MEASUREMENTS FROM TDRS
  - 13.5 GHz SGL DELOGGED SIGNAL ATTENUATION PLOTS FOR IDENTIFIED WEATHER EVENTS ('RAINDANCE')
  - COINCIDENT STEERING DATA: DATE/TIME/ ANTENNA AZ/EL (SINCE APRIL 94)

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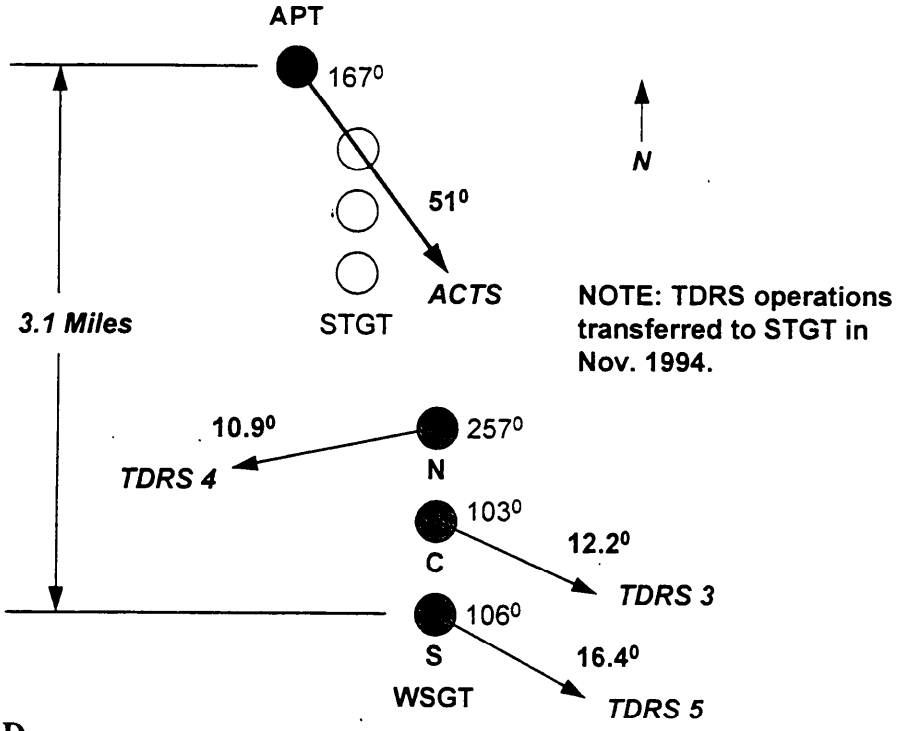
SITE CONFIGURATION



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ACTS K_A BAND MEASUREMENTS SUMMARY

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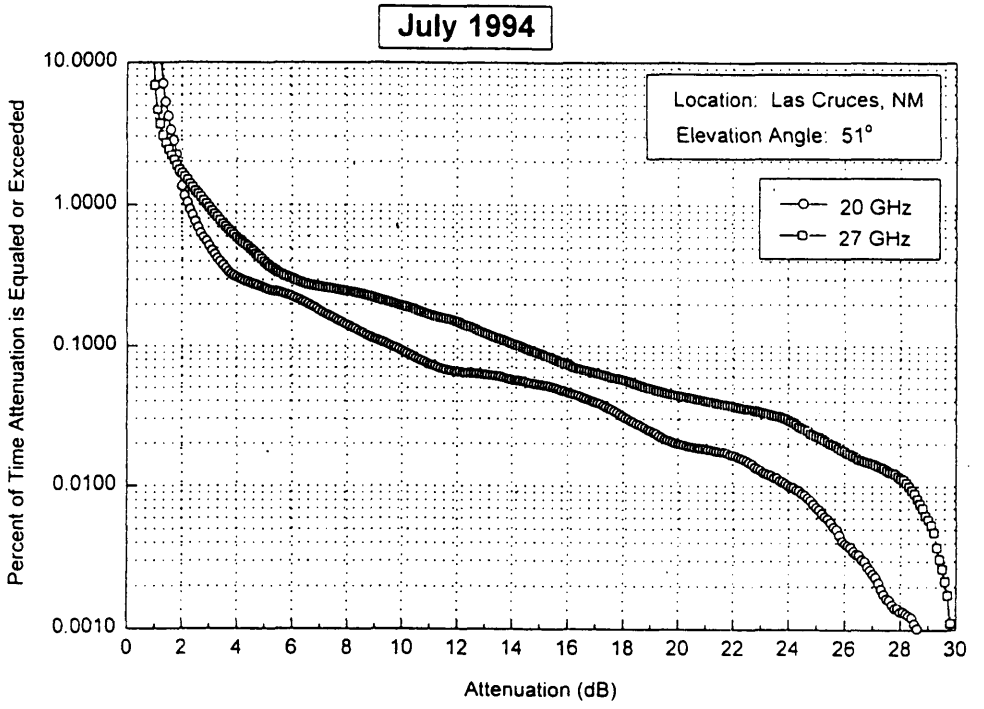
MONTHLY CUMULATIVE DISTRIBUTIONS FOR FREE SPACE ATTENUATION (AFS)



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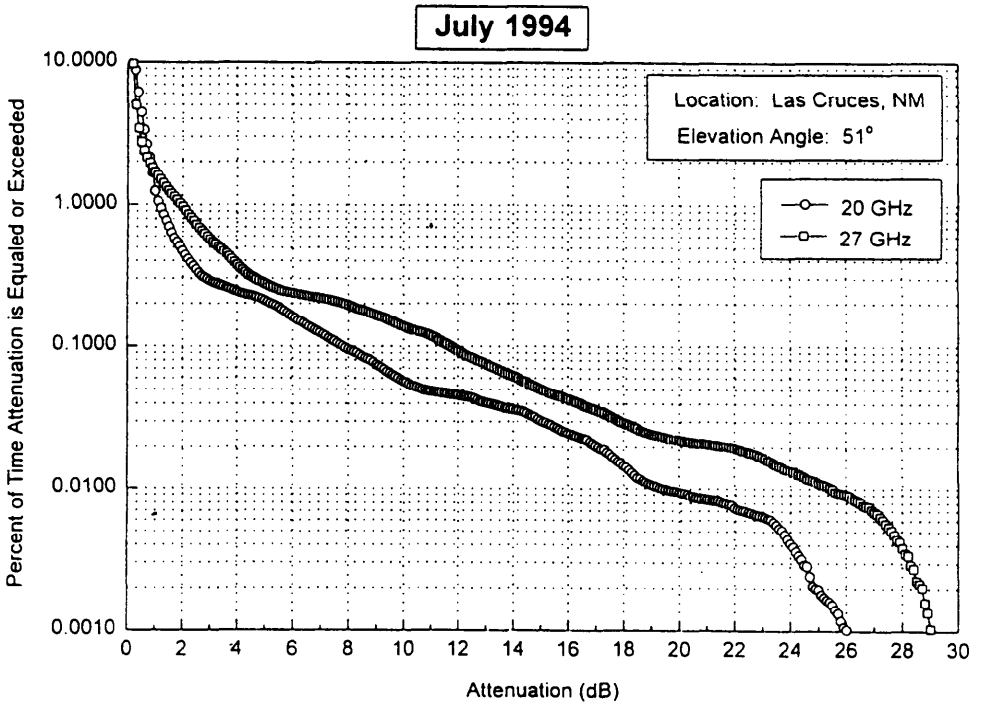
MONTHLY CUMULATIVE DISTRIBUTIONS FOR CLEAR AIR ATTENUATION (ACA)



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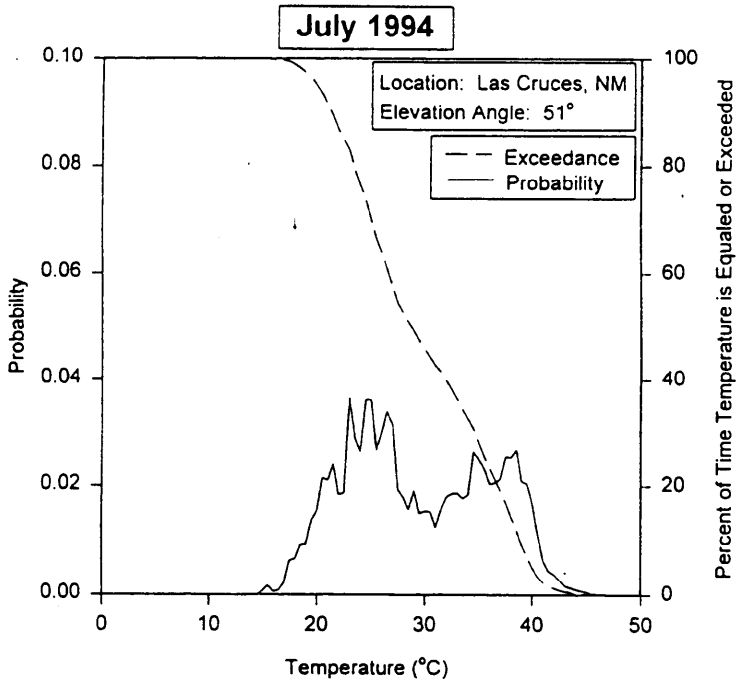
MONTHLY SURFACE TEMPERATURE



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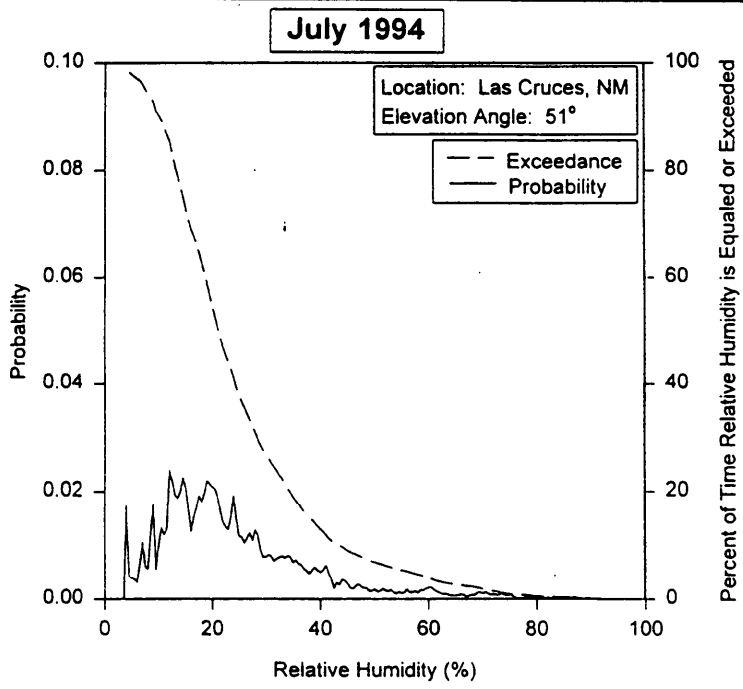
No data for July 17-20, 1994

MONTHLY SURFACE RELATIVE HUMIDITY



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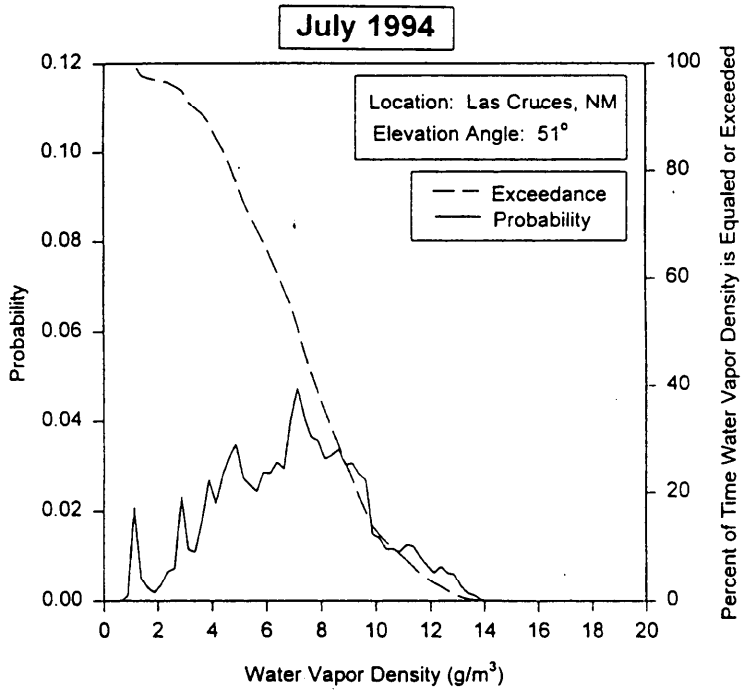
No data for July 17-20, 1994

MONTHLY SURFACE WATER VAPOR DENSITY



No data for July 17-20, 1994

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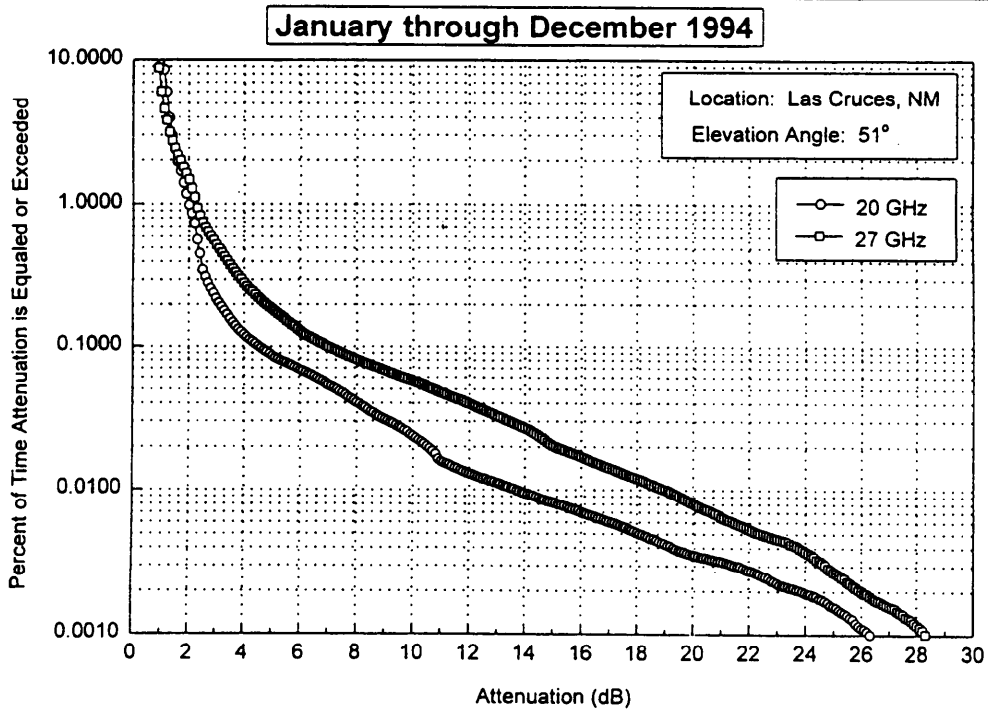
ANNUAL CUMULATIVE DISTRIBUTIONS FOR FREE SPACE ATTENUATION (AFS)



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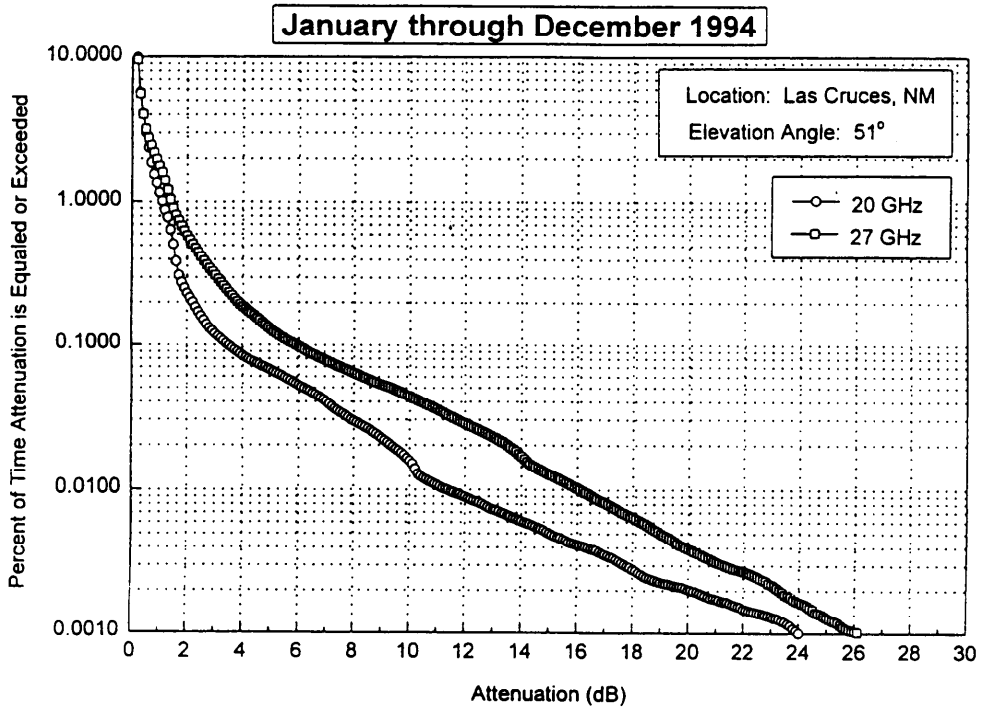
ANNUAL CUMULATIVE DISTRIBUTIONS FOR CLEAR AIR ATTENUATION (ACA)



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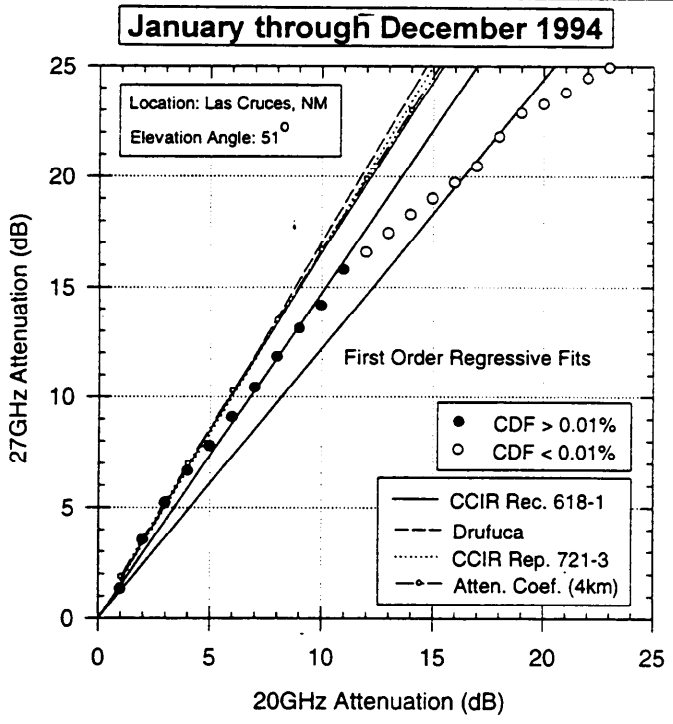
STATISTICAL ATTENUATION RATIO (ARS) FOR CLEAR AIR ATTENUATION (ACA)



All ARS points
Δ27/Δ20 = 1.2208
Best Fit: CCIR Rec. 618-1
Error: 1.8385

ARS points for CDF > 0.01%
Δ27/Δ20 = 1.4726
Best Fit: CCIR Rec. 618-1
Error: 0.1138

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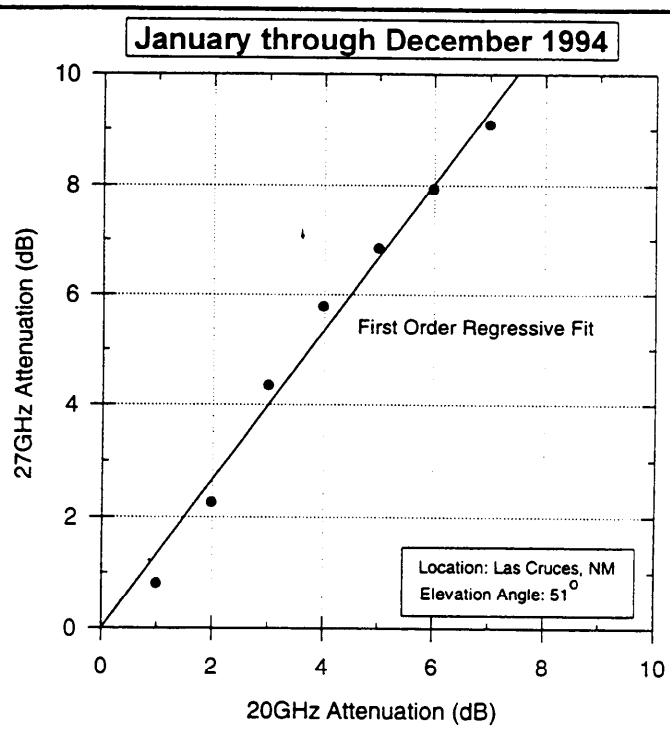
STATISTICAL ATTENUATION RATIO (ARS) FOR RADIOMETER DERIVED ATTENUATION (ARD)



All ARS points Δ27/Δ20 = 1.3356
All points have cdf % > 0.01%.

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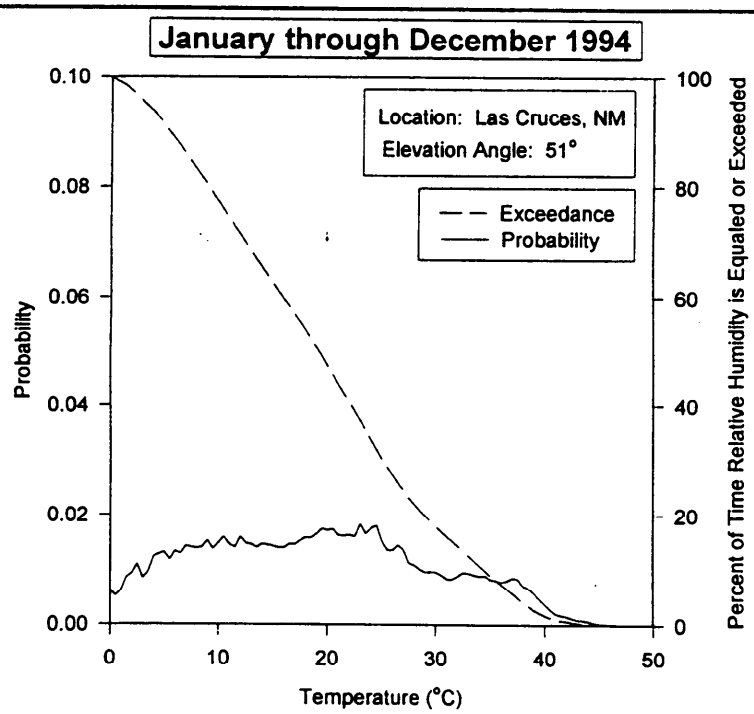
ANNUAL CUMULATIVE DISTRIBUTIONS FOR SURFACE TEMPERATURE



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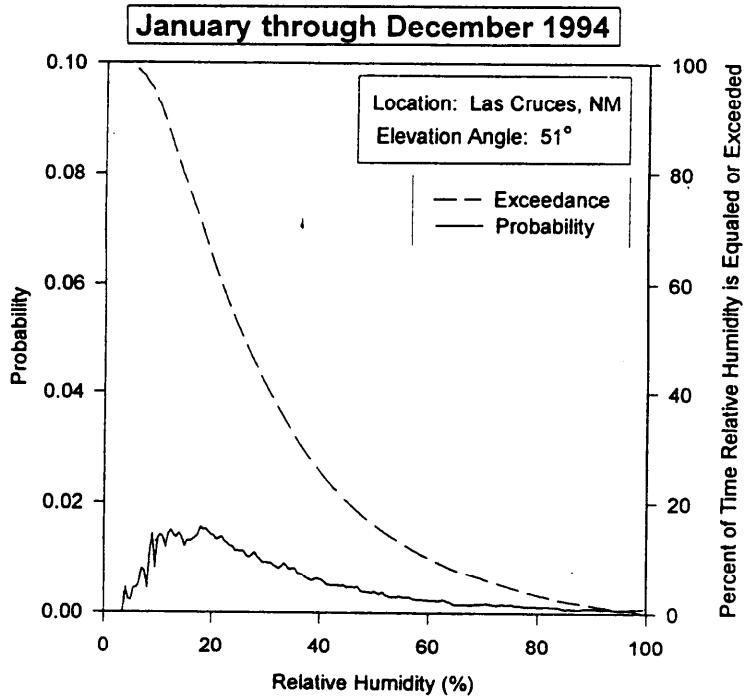
ANNUAL CUMULATIVE DISTRIBUTIONS FOR SURFACE RELATIVE HUMIDITY



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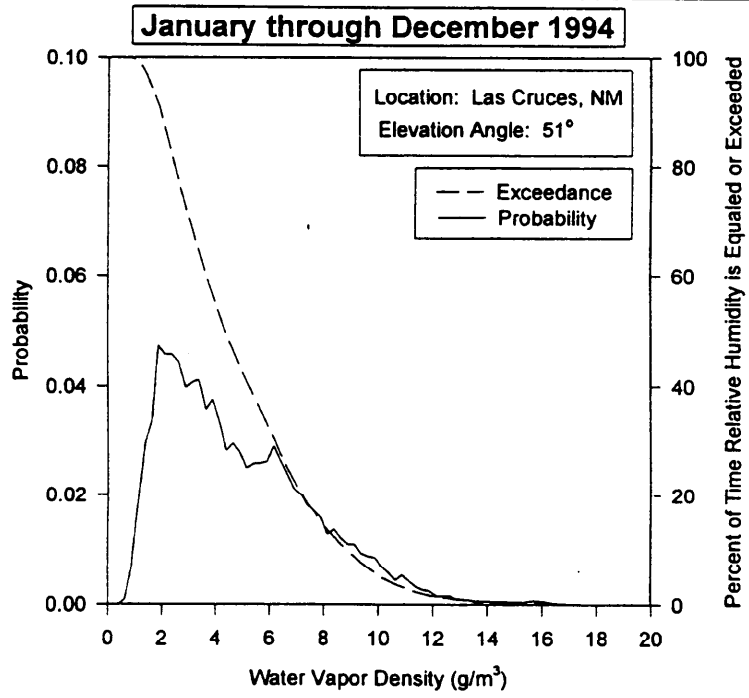
ANNUAL CUMULATIVE DISTRIBUTIONS FOR SURFACE WATER VAPOR DENSITY



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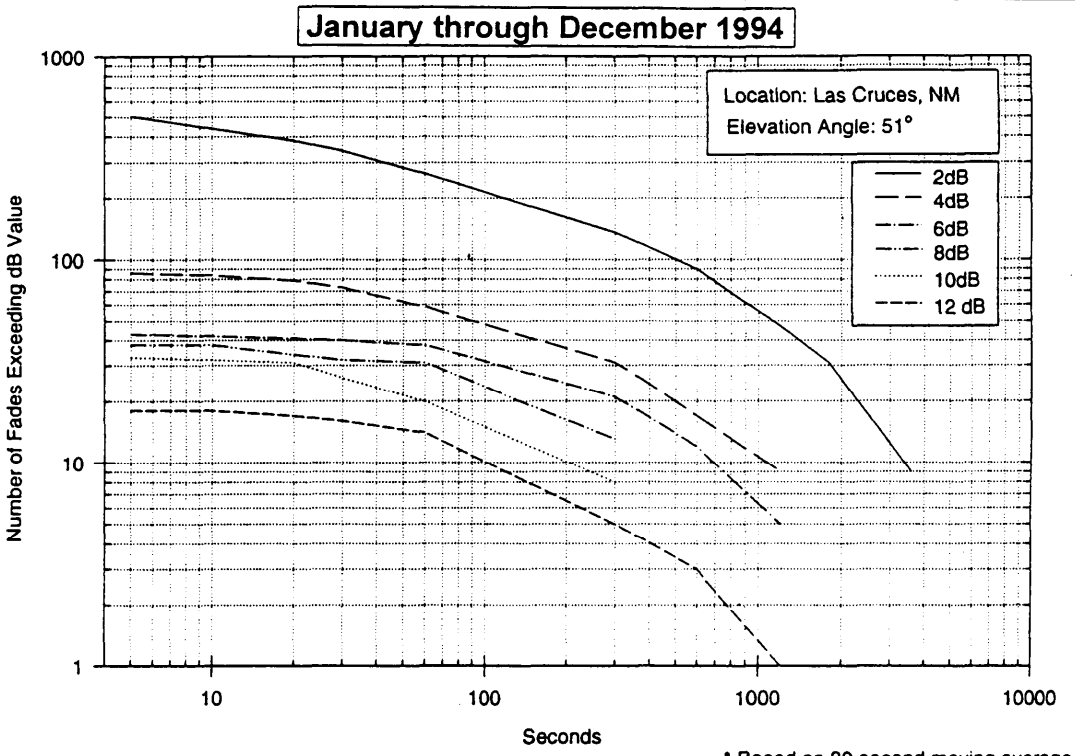
20 GHz FADE DURATION DISTRIBUTIONS



* Based on 30 second moving average

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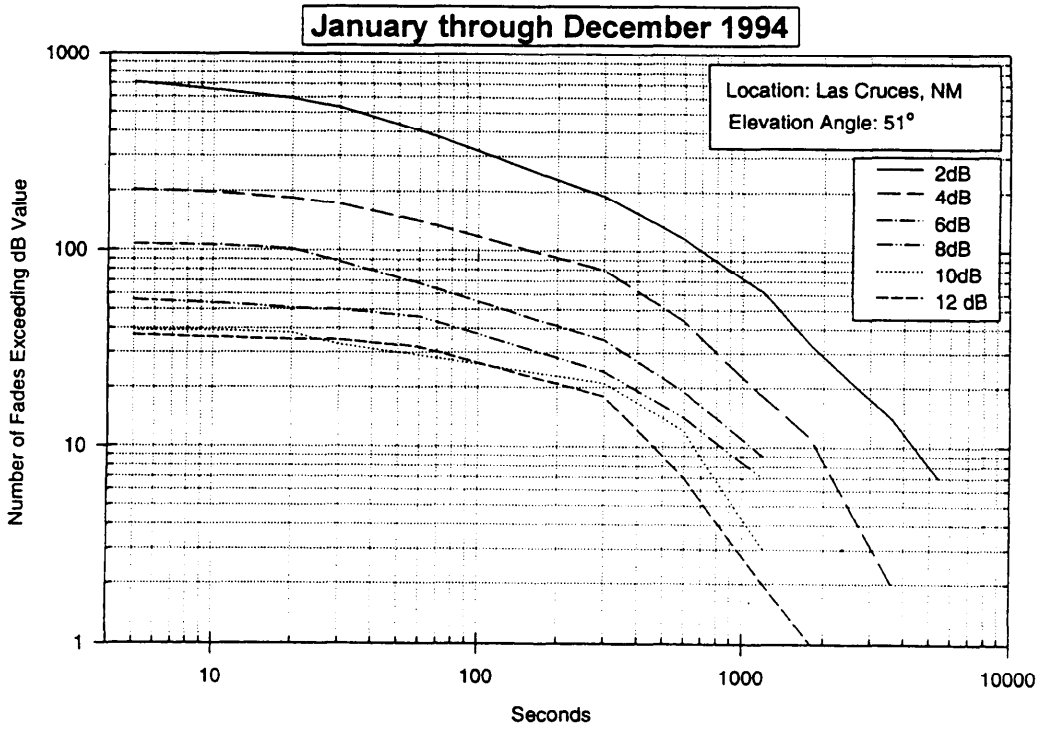
27 GHz FADE DURATION DISTRIBUTIONS



* Based on 30 second moving average

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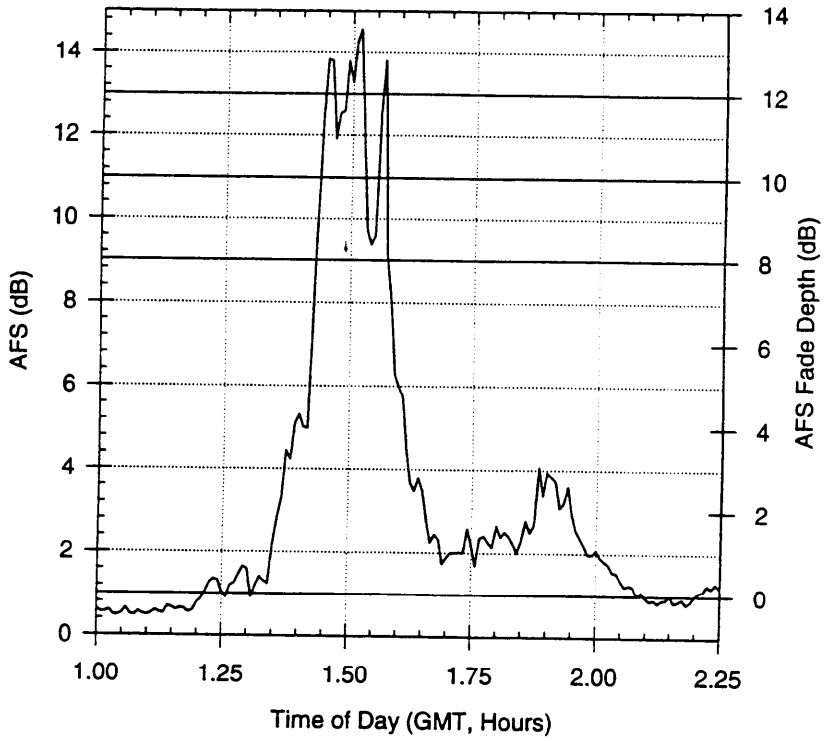
FADE EVENT ON NOVEMBER 3, 1994



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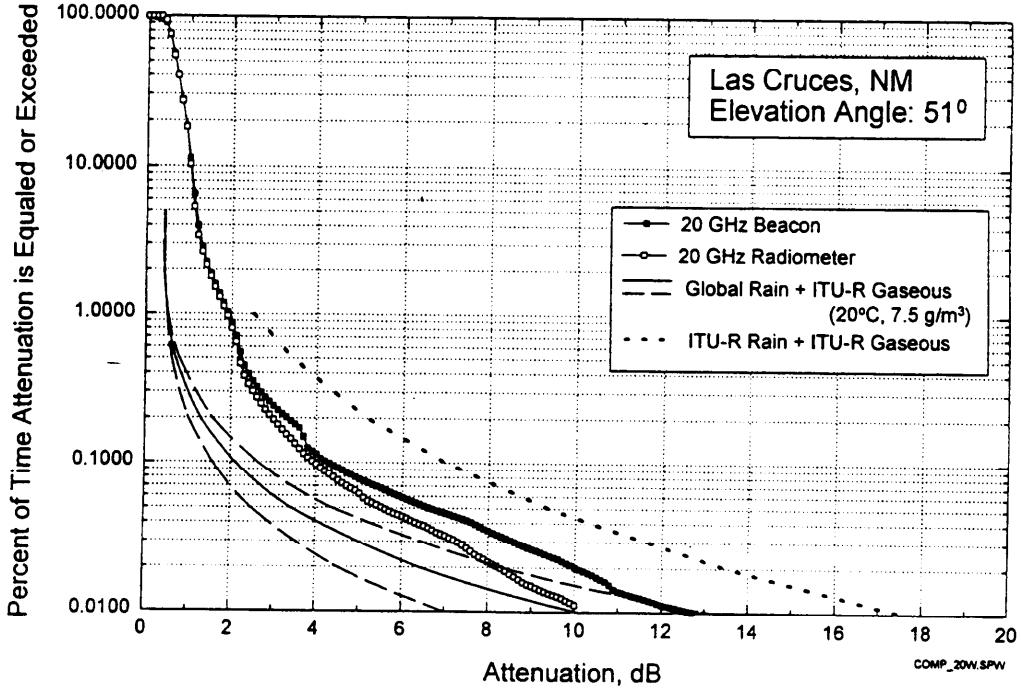
COMPARISON OF 20 GHz AFS DISTRIBUTIONS FOR CY 1994



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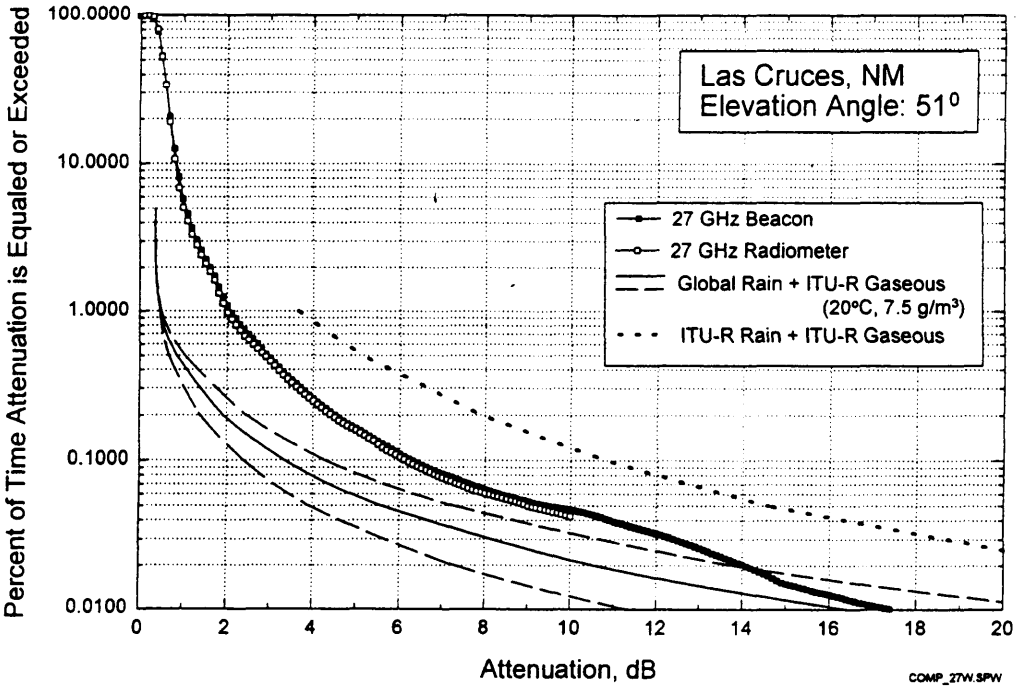
COMPARISON OF 27 GHz AFS DISTRIBUTIONS FOR CY 1994



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STATUS OF *.PV1 PROCESSING

- FIVE MONTHS PROCESSED
  - 1994: JULY, DECEMBER
  - 1995: JANUARY, FEBRUARY, MARCH
- INCONSISTENCIES BETWEEN CDF's GENERATED FROM *.pv0 AND FROM *.pv1
  - WITHIN EACH MONTH AND BETWEEN MONTHS
- CAUSE(S) OF INCONSISTENCIES UNDER INVESTIGATION
  - ACTSPP51
  - STeL POST PROCESSING

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APPLICATION OF ACTS MEASUREMENTS TO EVALUATION OF TDRS SPACE-TO-GROUND LINKS

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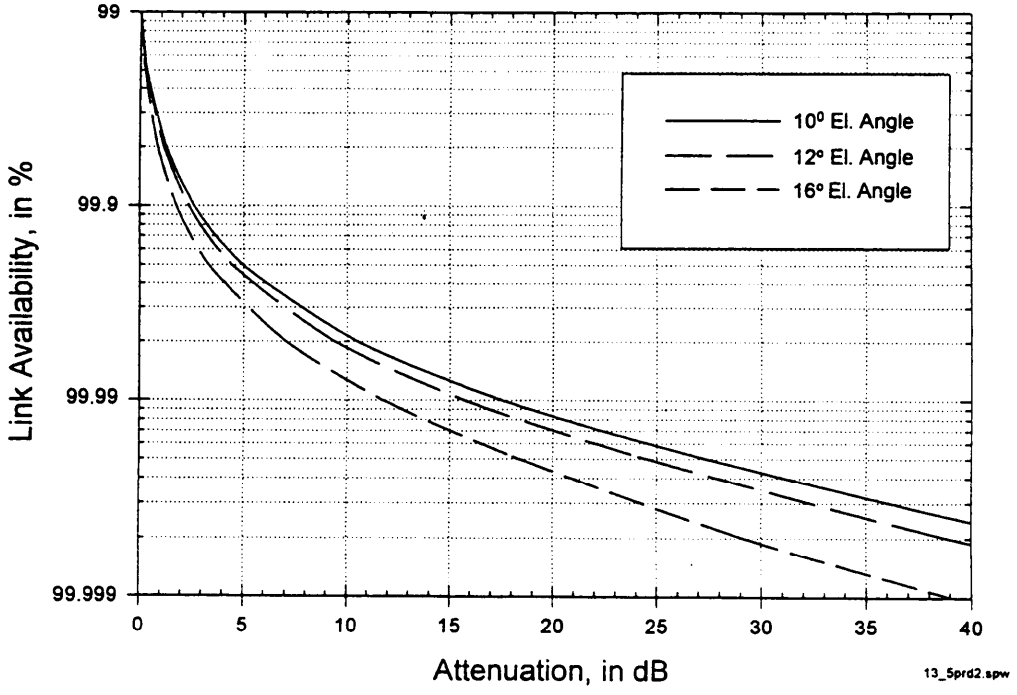
PREDICTED RAIN ATTENUATION DISTRIBUTIONS FOR TDRS 13.5 GHz SPACE-GROUND-LINKS FROM CRANE GLOBAL MODEL



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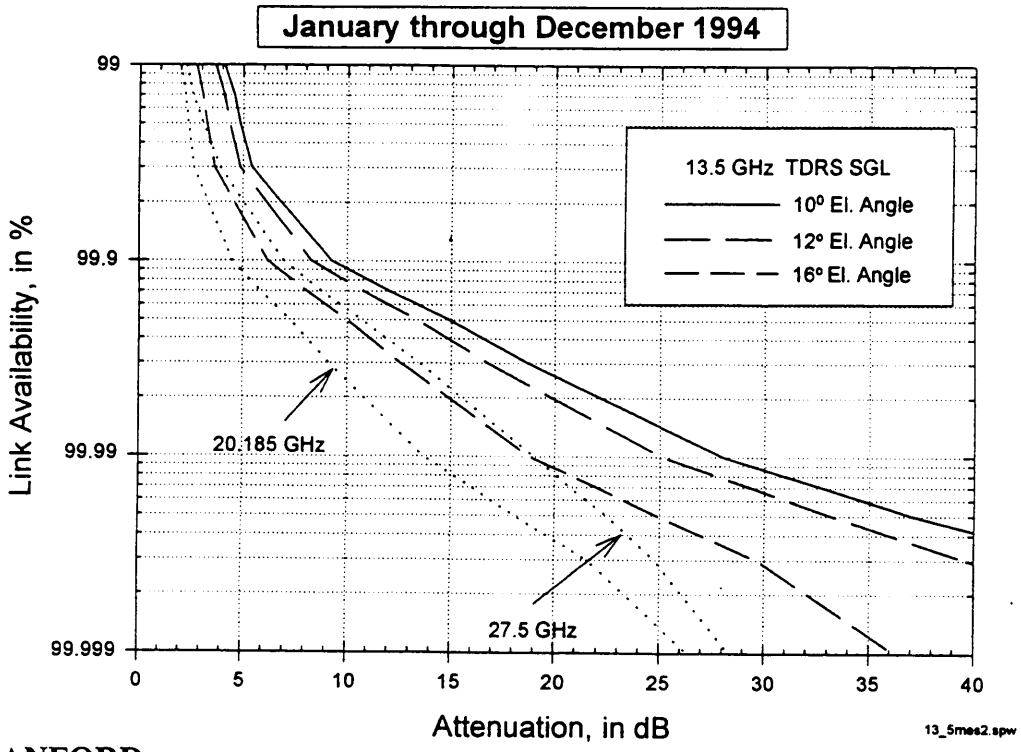
TDRS 13.5 GHz ANNUAL ATTENUATION DISTRIBUTIONS PREDICTED FROM MEASURED 20 & 27 GHz AFS DISTRIBUTIONS



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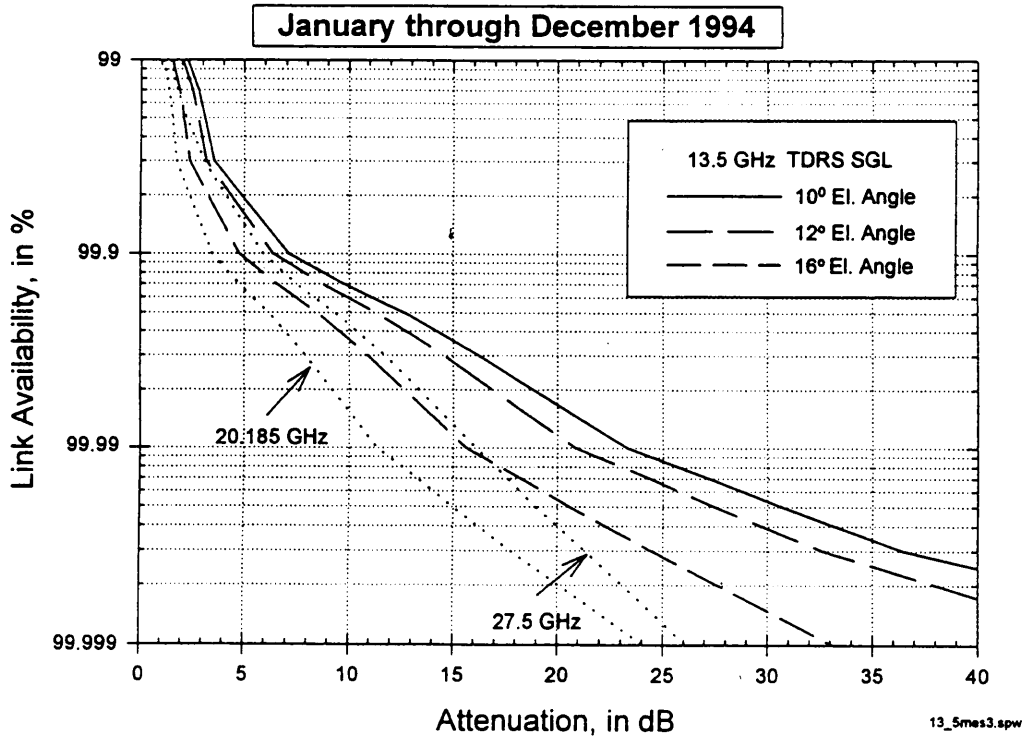
TDRS 13.5 GHz ANNUAL ATTENUATION DISTRIBUTIONS PREDICTED FROM MEASURED 20 & 27 GHz ACA DISTRIBUTIONS



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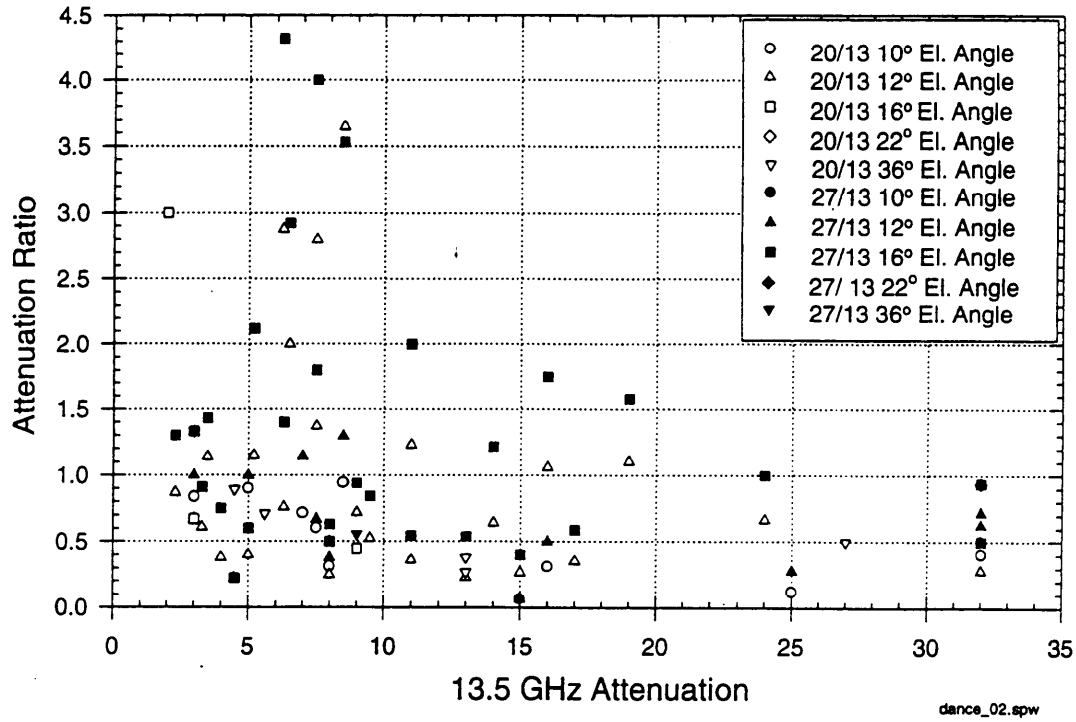
ATTENUATION RATIO FOR PEAK 13.5, 20.185, AND 27.5 GHz MEASUREMENTS



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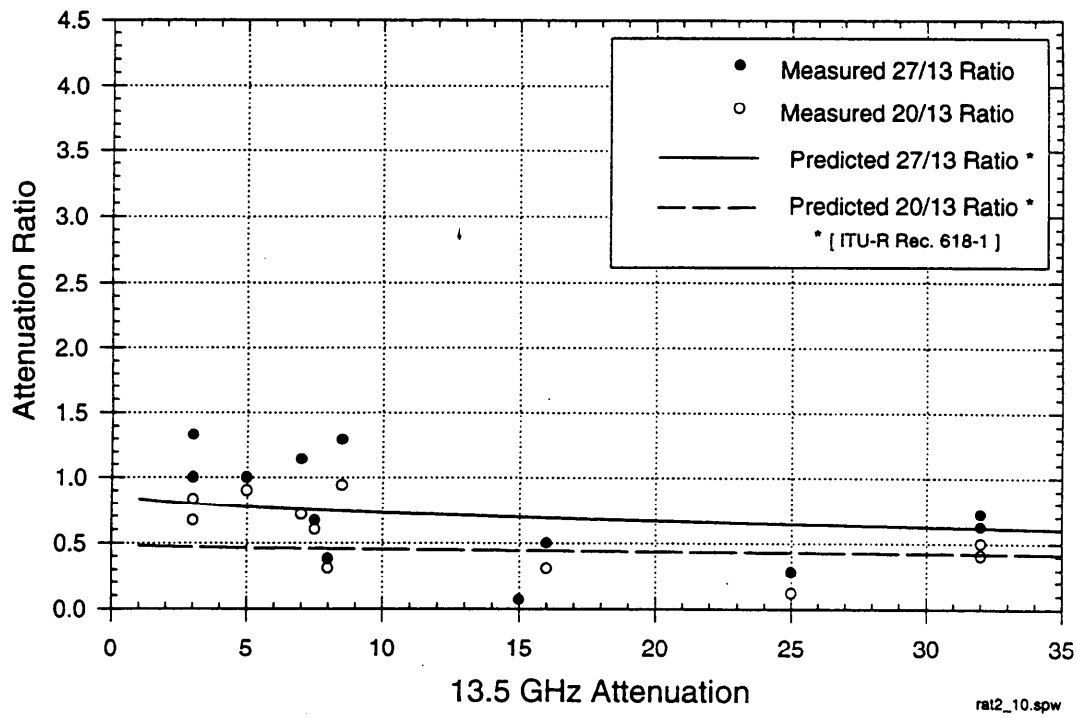
ATTENUATION RATIO MEASUREMENTS: ACTS & TDRS-E
Az = 257°, El = 10°



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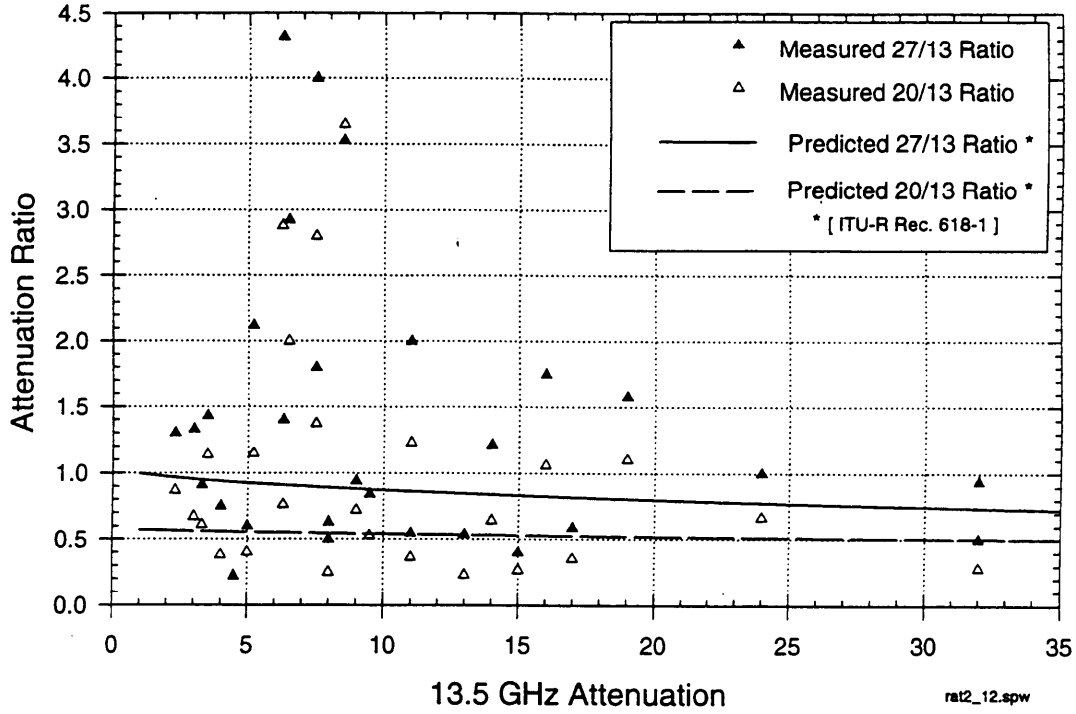
ATTENUATION RATIO MEASUREMENTS: ACTS & TDRS-D
Az = 103°, El = 12°



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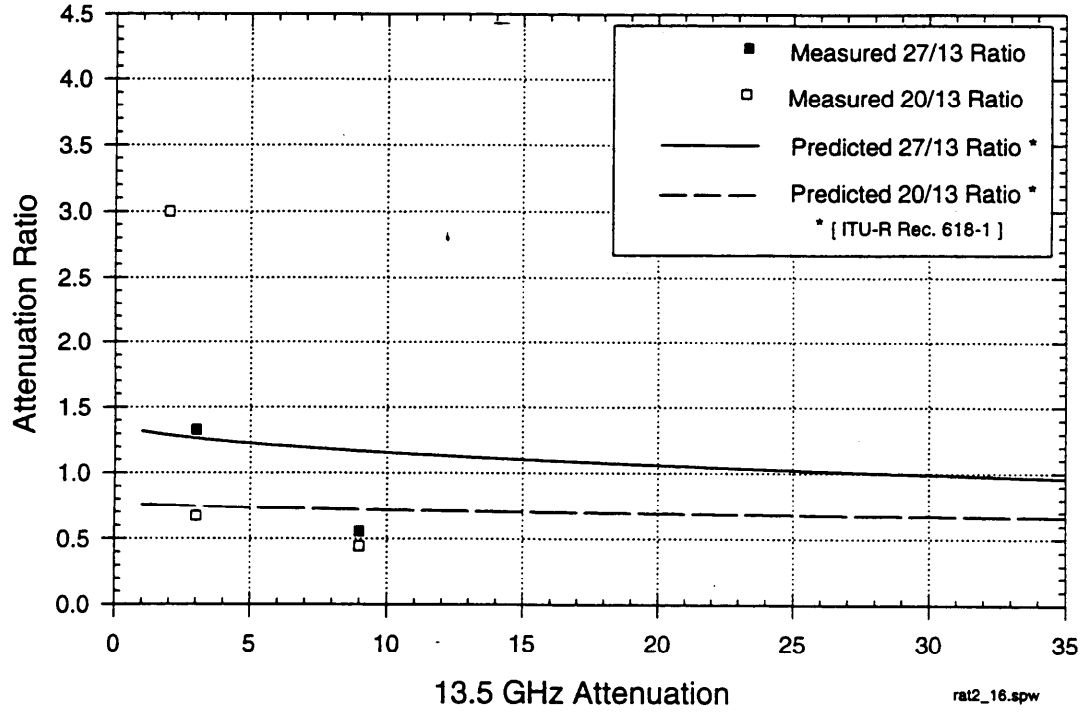
ATTENUATION RATIO MEASUREMENTS: ACTS & TDRS-5
Az = 106°, El = 16°



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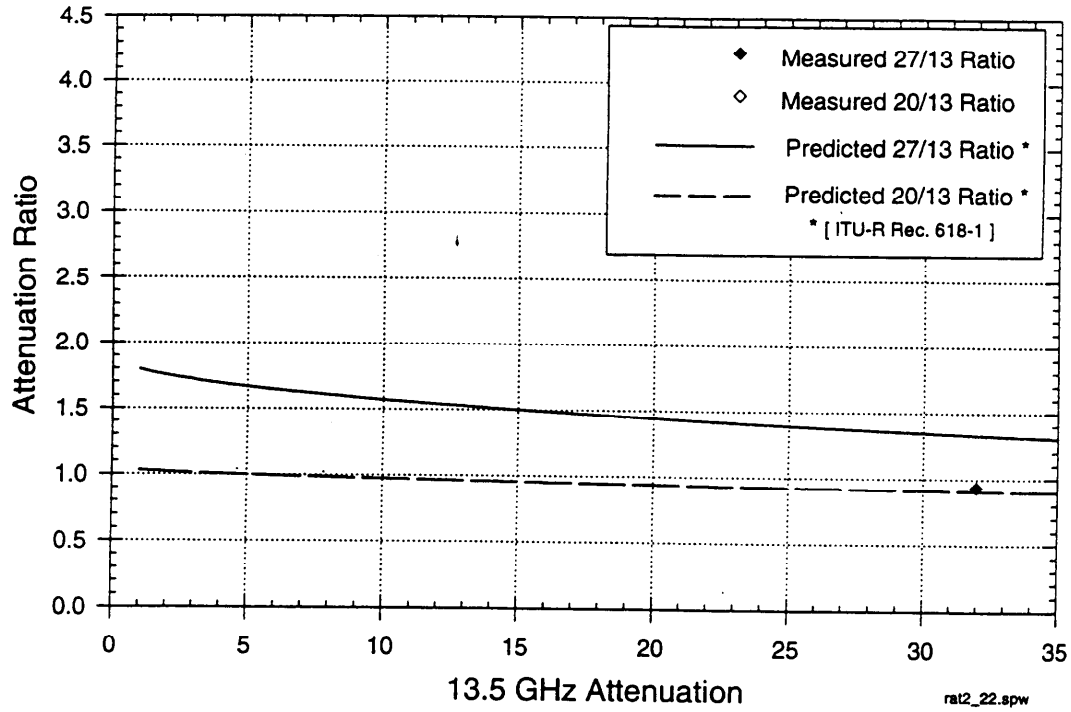
ATTENUATION RATIO MEASUREMENTS: ACTS & TDRS-C
Az = 250⁰, El = 22⁰



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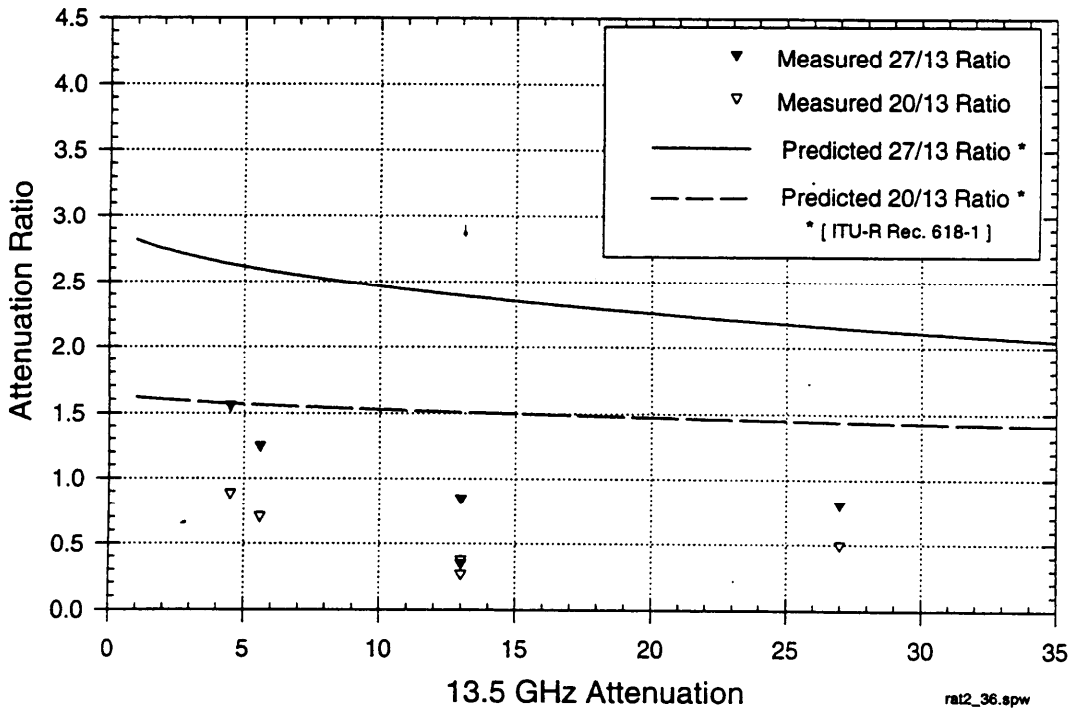
ATTENUATION RATIO MEASUREMENTS: ACTS & TDRS-C
Az = 131⁰, El = 36⁰



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SUMMARY FOR PEAK MEASURED ATTENUATION FOR TDRS 13.5 GHz SGL

January through November 1994

		TDRS SGL Elevation Angle					
		10^0	12^0	15^0 - 16^0	22^0	32^0	36^0
Measured Peak Attenuation		>32 dB	>32 dB	31 dB	>32 dB	14 dB	27 dB
Date		8/2-3	9/4	9/4	7/17	7/9	5/25
Duration (min)	> 1 dB	115	81	62	49.5	26	51
	>10 dB	33.5	42	27	21	6	6

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SUMMARY TDRS 13.5 GHz SGL PERFORMANCE

January through December 1994

Link Availability	*CY94 Attenuation (AFS) Exceedance (dB)**		
SGL El. Angle ►	10°	12°	16°
95%	2.56	2.29	1.72
99%	4.09	3.66	2.74
99.5%	4.85	4.34	3.25
99.7%	5.43	4.86	3.64
99.9%	9.27	8.30	6.21
99.95%	14.92	13.35	9.99
99.99%	28.05	25.10	18.79

* scaled from ACTS 27.5 and 20.185 GHz beacon measurements

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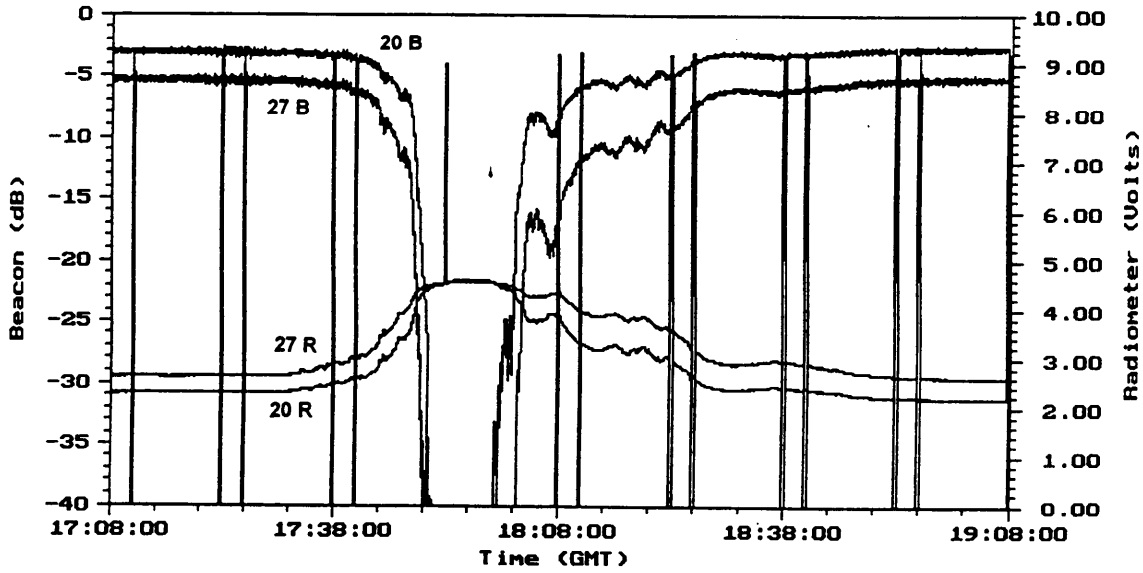
SEVERE RAIN EVENT - STel, RESTON, VA

May 18, 1995



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FUTURE ACTIVITIES

- GENERAL
  - COMPLETE DEVELOPMENT/DEBUG OF *.PV1 PRE-PROCESSING SOFTWARE
  - INCLUSION OF WHITE SANDS RADIOSONDE DATA FROM THE ARMY ATMOSPHERIC SCIENCES LAB
  - EXTEND ACTS LINK ANALYSIS WITH INITIATION OF STel RESTON FACILITY APT MEASUREMENTS (APRIL 95)

- APPLICATION OF ACTS MEASUREMENTS TO TDRS SGL'S
  - EXTEND ANALYSIS TO K_A-BAND SGL OPTIONS
  - DEVELOP ANNUAL FADE DEPTH/DURATION STATISTICS FOR SGL LINKS
  - EVALUATE LONG TERM FREQUENCY/ELEVATION ANGLE SCALING ALGORITHMS
  - INTEGRATE ELECTRONIC 'RAINDANCE' DATA INTO ACTS APT ANALYSIS

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NEW MEXICO APT STATUS REPORT

Stephen Horan
New Mexico State University

Presented at
ACTS Propagation Studies Workshop VII
June 15, 1995

I.1 STATISTICS: HOURS OF UP TIME

Operational Statistics						
		Total Time				
Month	**Status**	**Days**	**Hours**	**Minutes**	**Seconds**	**% of Total**
December	Up	31	0	0	0	100%
	Down	0	– 0	0	0	0%
January	Up	30	23	18	0	99.91%
	Down	0	0	42	0	0.09%
February	Up	28	0	0	0	100.00%
	Down	0	0	0	0	0.00%
March	Up	31	0	0	0	100.00%
	Down	0	0	0	0	0.00%
April	Up	29	23	34	50	99.95%
	Down	0	0	25	10	0.05%
May	Up	30	22	18	45	99.77%
	Down	0	1	41	15	0.23%
Total	Up	181	21	11	35	99.94%
	Down	0	2	48	25	0.06%

I.2 CALIBRATION: DATES OF ALL CALIBRATIONS, EXTERNAL AIR TEMP AT CALIBRATION

Calibration Record		
Month	**Day**	**Air Temperature (°C)**
December	none performed	
January	20	12.40
	20	11.30
February	6	17.50
	18	11.50
March	2	16.40
	17	23.70
April	3	23.80
	17	15.40
May	1	27.60
	8	23.20
	26	30.00

I.3 CALIBRATION: DATES OF CRG CALIBRATIONS

CRG Calibration Record	
Month	**Date**
December	7
	16
	19
	27
January	20
February	6
	18
March	2
April	3
	17
May	1
	26

I.4 SUN INTRUSION DATES

March SUN INTRUSION DATES	
DATE	SATURATING?
4	no
5	no
6	20 GHz only
7	Both channels
8	Both channels
9	no
10	no

I.5 OPERATIONS CHANGES/PROBLEMS

1. FEED HORN CRACKED IN JANUARY - REPLACED WITH SPARE

2. APRIL 23 LOSS OF TIME DUE TO SITE-WIDE POWER GLITCH?

3. APRIL 28 HAD KEYBOARD HANG AND SYSTEM DID NOT RE-BOOT PROPERLY - LOST DATA
   - TIME ON REAL-TIME DISPLAY AND RUNNING GRAPH IS 3 TO 5 MINUTES DIFFERENT
   - WWV TIME IS USUALLY ONLY RECEIVED A FEW TIMES PER WEEK ACCORDING TO CTS-10 SOFTWARE

4. INSTALLED RF TEMPERATURE CONTROLLER AND UPPER SHROUD

5. UNSUCCESSFUL IN MAKING THE NEW PREPROCESSING SOFTWARE CONVERGE CORRECTLY TO REALISTIC VALUES

2.1 OTHER ACTIVITIES

1. RAIN GAUGE CALIBRATION REPORT FINISHED
   - RECOMMEND THAT A SMOOTHING ALGORITHM BE USED RATHER THAN TWO-POINT SLOPES AS COMPUTED WITH ACTSVIEW

2. SUN INTRUSION PREDICTION PROGRAM GENERATED
   - MARYLAND REPORTS SEVERAL HOURS DIFFERENCE BETWEEN PREDICTED AND ACTUAL INTRUSION
   - NEW MEXICO PREDICTIONS ARE CORRECT
   - IF ANYONE WISHES TO SEND ME THEIR ACTUAL INTRUSION TIMES, I WILL TRY TO FIND THE PROBLEM!

3. GLENN FELDHAKE HAS GRADUATED AND MOVED ONTO WORKING FOR LOU IPPOLITO AT STEL.