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Data Report ERL WPL-2



DATA REPORT ON MEASUREMENTS OF PRECIPITABLE WATER VAPOR
AND CLOUD LIQUID AT FORT SILL, OK, SESAME 1979

F. O. Guiraud
J. Howard
D. C. Hogg

Wave Propagation Laboratory
Boulder, Colorado
October 1979

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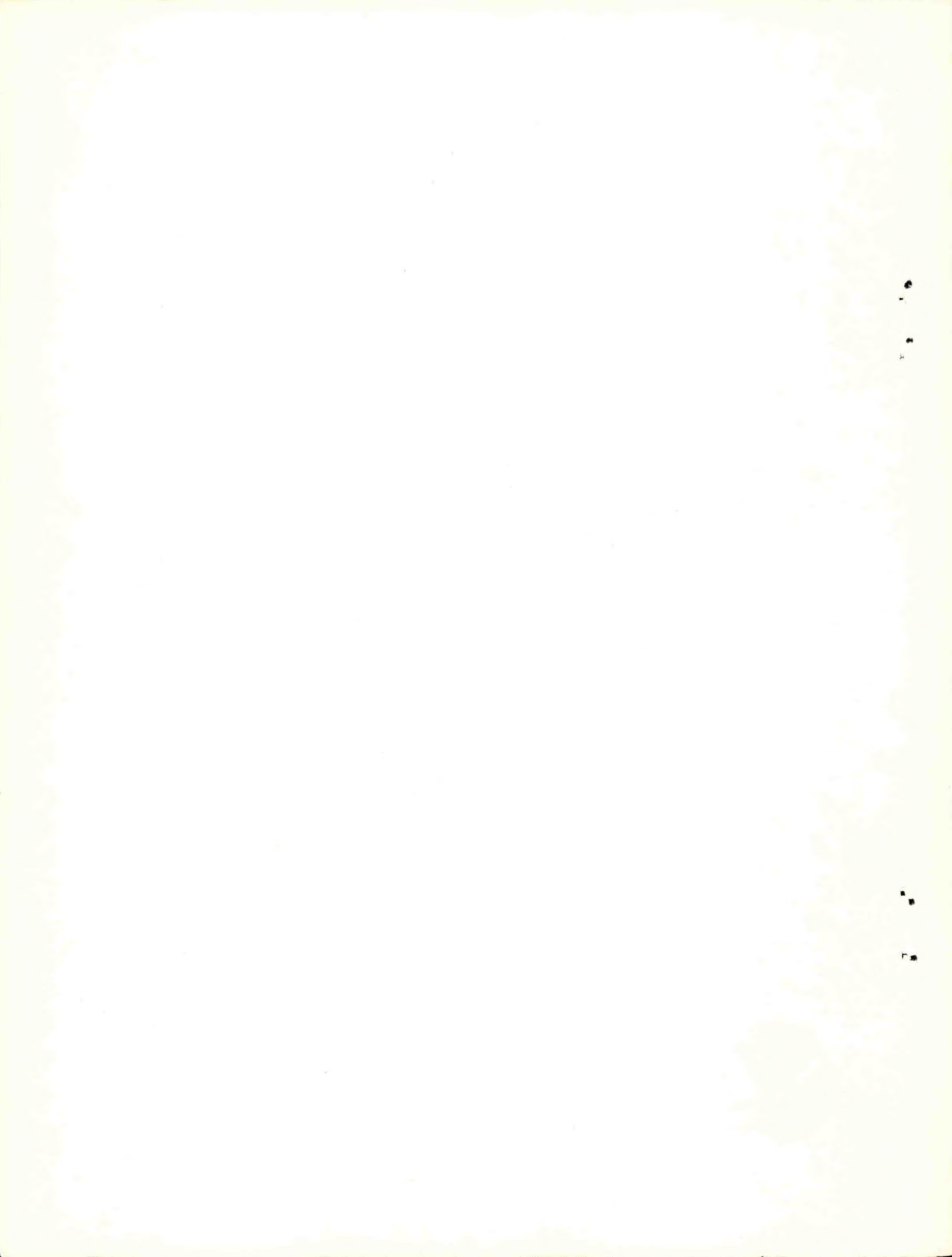
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CONTENTS

	Page
1. INTRODUCTION	1
2. LOCATION	1
3. RADIOMETRIC EQUIPMENT	2
4. RETRIEVAL OF PRECIPITABLE WATER VAPOR AND LIQUID IN THE ZENITH	2
5. DISCUSSION OF THE DATA	4
LIST OF TABLES	6
LIST OF FIGURES	8

DATA REPORT ON MEASUREMENTS OF PRECIPITABLE WATER VAPOR
AND CLOUD LIQUID AT FORT SILL, OK, SESAME 1979

F. O. Guiraud, J. Howard, and D. C. Hogg

1. INTRODUCTION

A two channel microwave radiometer was operated from March 29, 1979 to June 8, 1979 for the National Center of Atmospheric Research, Boulder, CO for the measurement of precipitable water vapor as part of the 1979 Severe Environmental Storms and Mesoscale Experiment (SESAME) program conducted by the Severe Storms Laboratory at Norman, OK. The radiometers were located on the Fort Sill military base at Lawton, OK, approximately 140 miles southwest of Norman, OK, to provide a continuous monitor of total precipitable water vapor as it flows from the Gulf of Mexico into the SESAME monitoring area. The microwave radiometer operated essentially continuously, except for a two week period at the end of May when its computer failed requiring repair by the manufacturer. Included in this data report are the summaries of the measurements of precipitable water vapor, and condensed water (cloud liquid and rain), along with vapor measurements obtained from radiosonde measurements at Fort Sill and Oklahoma City, OK. Also included are rainfall summaries toward the end of the measurement period when a rain gauge was installed at the radiometer site.

2. LOCATION

The radiometers at the Fort Sill base were located inside the security fence on the west side of the I-SEE-0 Hall, approximately 5 meters south of the western fence boundary, and approximately 60 meters south of the northern fence boundary. This location corresponds to 34.6 degrees latitude and 98.4 degrees longitude. The location is 360 meters above sea level.

3. RADIOMETRIC EQUIPMENT

The 21 and 32 GHz radiometers used in SESAME are the pair normally in continuous operation at the Denver, CO, WSFO. A description of their design, construction, and calibration is given in reference (1)*. The outputs of the radiometers provide simultaneously precipitable water vapor (in cm) and integrated liquid (in mm) in the vertical every five minutes.

4. RETRIEVAL OF PRECIPITABLE WATER VAPOR AND LIQUID IN THE ZENITH

A statistical inversion technique is used for retrieval of precipitable water vapor, V , and integrated liquid in the zenith, L from the radiometric measurements. The algorithms are based on the fact that the amounts of V and L are proportional to the absorptions at the two frequencies obtained from the radiometric measurements. In other words, the total absorption is the sum of absorption due to vapor, $(V\alpha_v)$, liquid, $(L\alpha_l)$, and any other contributing sources, i.e., oxygen†. The mass absorption coefficients α_v and α_l vary sufficiently at the two chosen measurement frequencies (also inversely in magnitude for V and L) such that that one can solve the resulting equations for V and L .

In practice the coefficients for these linear equations are determined statistically by calculating the total absorptions using local historical radiosonde profiles as a guide. For V the radiosonde profile can be used directly, but for L one must improvise since we have no direct in-situ measurement of L ; cloud liquid is added to the historical profiles when the RH is high enough to indicate that liquid may be present ($RH > 95\%$). Linear fits of the resulting modeled absorptions versus their V , L values determine the coefficients for the linear equations.

* F. O. Guiraud, J. Howard, and D. C. Hogg, "A Dual-Channel Microwave Radiometer for Measurement of Precipitable Water Vapor and Liquid," accepted for publication in a Special Issue of IEEE Trans. on Geoscience Electronics.

† Oxygen contributions at these frequencies can be treated as a constant.

The equations used for the present data are based on 349 radiosonde profiles from Oklahoma City from 1975-1977, for the months of April and May. From the 349 profiles 94 had humidities within the profile that indicated that liquid water could be present; these were used for modeling cloud liquid.

The resulting equations are:

$$V = -.01 + 29.42 \tau_{21} - 12.47 \tau_{32}$$

$$L = -.014 - .438 \tau_{21} + .747 \tau_{32}$$

where τ_{21} and τ_{32} are absorptions at 21 and 32 GHz obtained from the radiometric measurements of brightness temperatures, T_B (in K). The relationship between absorption and brightness temperature is:

$$\tau = - \ln \left(\frac{T_M - T_B}{T_M - 2.9} \right)$$

where the 2.9 K is the cosmic background radiation, and T_M is a frequency-dependent constant. The T_M values are derived from the radiosonde data set mentioned earlier:

$$T_{M_{21}} = 278.5 \text{ K}$$

$$T_{M_{32}} = 276.0 \text{ K.}$$

The estimated accuracies for the measurements of precipitable water vapor and integrated liquid are 0.14 cm rms and 0.1 mm rms respectively.

Comparison of radiometrically derived precipitable water vapor with radiosonde measured vapor made at Denver, CO during the six months preceding the Fort Sill measurements, resulted in a 0.17 cm rms difference between the

two. This calibration lends a high degree of confidence to the measurements of precipitable water vapor by the radiometers; the actual accuracy is difficult to establish because measurements of precipitable water vapor by some radiosondes are questionable.

5. DISCUSSION OF THE DATA

The Fort Sill measurements of V and L are averages of 10 second samplings over a period of 5 minutes. All data presented in this report are the 5 minute averages. These averages were recorded on magnetic diskettes. The bulk of this report, Figs. 1 through 62, are microfilm plots of the 5 minute data points. Both V and L are included on each of the daily plots. The upper curve on the plots is V; L generally will be near zero (in the absence of liquid-bearing clouds and rain) to the extent of measurement error (± 0.1 mm rms of liquid). Tables 1 through 8 provide a listing of V and L every half hour.

Table 9 states the periods that measurements were lost due to power and computer failure, or purposely deleted because our presently-used algorithm is not yet designed to provide recovery of vapor in the presence of rain. The lower portions of Table 9 are periods when the data on the computer diskette were lost. But every half hour the current 5 minute average was printed on a terminal at the radiometer site. For the "lost" data, a simpler algorithm was used and the latest hardware calibration factors were not included. It is believed that this has little effect on V, but that the values of L should be used with caution. These "lost" points are included in the microfilm plots as the circled points, but are not differentiated from other data in Tables 1 through 8.

To improve identification of anomalies in our data base, a weighing-bucket rain gauge was borrowed from the National Severe Storms Laboratory and operated next to the radiometers, starting May 10, 1979. The chart records, scaled by periods of approximately constant rain rate, are reproduced as Table 10.

Also, radiosonde records were collected from routine releases from two locations at Fort Sill and from the National Weather Service at Oklahoma City. The humidity profile from each release was integrated for precipitable water vapor and compared with the radiometric vapor data. The humidity integrations are summarized in Tables 11 through 13. Releases at the I-SEE-0 Hall, Table 11, were made approximately 150 meters from the radiometer site; they are performed as classroom training exercises by the students in military schools. Summaries in Table 12 are the official radiosonde releases at Fort Sill, located two blocks east of the radiometers. Please note, for both, that these are low altitude soundings. Soundings reaching 400 mb heights include essentially all the atmospheric vapor. Those reaching lower heights should be compared with caution with the radiometric data.

We believe the amounts of precipitable water vapor obtained from the radiometers to be correct except during periods of heavy rain. Consider, as an example, May 20, 1979. During the day, the vapor built up to more than 4 cm at which time (1400 hrs) a heavy shower with a maximum rainrate of 80 mm/hr over a 20 minute period occurred (one inch of rain). During the shower, the amount of vapor is not shown because it is considered to be in error. A similar example occurs on June 4 through June 5, 1979 when the precipitable water vapor increased from 2.3 to 4.4 cm, at which time (1000 hrs) a 40 mm/hr rain lasting more than 2 hrs occurred. Another example runs from 900 hrs, April 9 to 900 hrs April 10 during which the precipitable water vapor increased by a factor of 4 (from 0.5 to cm); this was followed by tornado activity at Lawton.

Acknowledgments

Special thanks must be expressed to Commander Jeffrey G. Carlen, the NOAA Liaison Officer stationed at Fort Sill. He performed his titled function beyond expectations. Besides providing us location, power, and supplying many supplementary pieces of data, he operated and maintained the radiometers for the total period of the SESAME experiment. The 75th Field Artillery Group at Fort Sill through CW4 Robert N. Sterrett and CW3 Whatley provided us the radiosonde profiles.

LIST OF TABLES

- Table 1. Half hour listings of 5 minute averaged microwave radiometric measurements of precipitable water vapor for March 1979 at Fort Sill, OK.
- Table 2. Half hour listings of 5 minute averaged microwave radiometric measurements of precipitable water vapor for April 1979 at Fort Sill, OK.
- Table 3. Half hour listings of 5 minute averaged microwave radiometric measurements of precipitable water vapor for May 1979 at Fort Sill, OK.
- Table 4. Half hour listings of 5 minute averaged microwave radiometric measurements of precipitable water vapor for June 1979 at Fort Sill, OK.
- Table 5. Half hour listings of 5 minute averaged microwave radiometric measurements of integrated liquid water in the zenith for March 1979 at Fort Sill, OK.
- Table 6. Half hour listings of 5 minute averaged microwave radiometric measurements of integrated liquid water in the zenith for April 1979 at Fort Sill, OK.
- Table 7. Half hour listings of 5 minute averaged microwave radiometric measurements of integrated liquid water in the zenith for May 1979 at Fort Sill, OK.
- Table 8. Half hour listings of 5 minute averaged microwave radiometric measurements of integrated liquid water in the zenith for June 1979 at Fort Sill, OK.
- Table 9. Listing of outage periods in data recordings.
- Table 10. Rainfall at the radiometer site from May 10, 1979 through June 11, 1979.

Table 11. Radiosonde derived precipitable water vapor from releases at the I-SEE-O Hall at Fort Sill, OK.

Table 12. Radiosonde derived precipitable water vapor from releases by the 75th Field Artillery Meteorology Group, Fort Sill, OK.

Table 13. Radiosonde derived precipitable water vapor from the National Weather Service releases at Oklahoma City, OK.

LIST OF FIGURES

Figures 1 through Figure 62 - Microwave radiometric measurements of precipitable water vapor (upper curve) and integrated liquid water in the zenith (lower curve) recorded at Fort Sill, OK.

PRECIPITABLE WATER VAPOR - TABLE FOR: MARCH 1979 - FORT SILL OK

HR (CST) / DAY OF MONTH...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			
0100 (CM)																																2.2	1.0	
0130 (CM)																																	2.1	1.0
1100 (CM)																																	1.9	1.0
1130 (CM)																																	1.9	1.0
2100 (CM)																																	1.4	1.0
2130 (CM)																																	1.4	1.0
3100 (CM)																																	1.2	1.0
3130 (CM)																																	1.1	1.0
4100 (CM)																																	1.1	1.0
4130 (CM)																																	1.1	1.0
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20130 (CM)																																	1.0	1.0
21100 (CM)																																	1.0	1.0
21130 (CM)																																	1.0	1.0
22100 (CM)																																	1.0	1.0
22130 (CM)																																	1.0	1.0
23100 (CM)																																	1.0	1.0
23130 (CM)																																	1.0	1.0

PRECIPITABLE WATER VAPOR - TABLE FOR: JUNE 1979 - FORT SILL OK

HR (CST) / DAY OF MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0100 (CH)			2.7	2.3	4.2	3.5	3.7																							
0130 (CH)		3.5	2.7	2.4	4.1	3.4	3.7																							
1100 (CH)		3.3	2.7	2.4	4.0	3.3	3.6																							
1130 (CH)		3.5	2.7	2.5	3.8	3.1	3.5	3.8																						
2100 (CH)		3.5	2.7	2.5	4.0	3.2	3.4																							
2130 (CH)		3.5	2.7	2.4	3.7	3.2	3.4																							
3100 (CH)		3.6	2.7	2.4	3.7	3.2	3.2																							
3130 (CH)		3.6	2.8	2.4	3.6	3.5																								
4100 (CH)		3.6	2.8	2.4	3.7	3.3																								
4130 (CH)		3.6	2.8	2.4	3.7	3.1																								
5100 (CH)		3.5	2.8	2.4	3.7	3.0																								
5130 (CH)		3.4	2.7	2.5	3.9	3.3																								
6100 (CH)		3.4	2.6	2.6	4.1	3.4																								
6130 (CH)		3.5	2.9	2.6	4.0	3.3																								
7100 (CH)		3.5	2.8	2.6	4.0	3.3																								
7130 (CH)		3.4	2.6	2.7	4.1	3.2																								
8100 (CH)		3.4	2.7	3.0	4.2	3.5																								
8130 (CH)		3.4	2.7	3.0	4.5	3.5	3.0																							
9100 (CH)		3.4	2.6	3.0	4.3	3.3	3.0																							
9130 (CH)		3.3	2.7	3.0	4.5	3.3	3.0																							
10100 (CH)		3.3	2.6	3.0	4.5	3.4	2.9																							
10130 (CH)		3.1	2.6	3.0	3.6	3.0	3.0																							
11100 (CH)	2.9	3.1	2.7	2.9	3.5	3.0	3.0																							
11130 (CH)	3.0	3.1	2.8	2.9	3.6	3.2	3.0																							
12100 (CH)	3.0	3.1	2.7	2.9	3.5	3.1	3.0																							
12130 (CH)	3.1	3.1	2.7	2.9	3.5	3.2	3.0																							
13100 (CH)	3.1	3.1	2.6	3.0	4.2	3.6	3.2																							
13130 (CH)	3.1	3.1	2.6	3.1	4.3	3.5	3.2																							
14100 (CH)	3.2	3.0	2.6	3.3	4.4	3.5	3.2																							
14130 (CH)	3.2	3.1	2.5	3.3	4.4	3.5	3.2																							
15100 (CH)	3.4	3.2	2.4	3.4	4.3	3.8	3.3																							
15130 (CH)	3.4	3.1	2.4	3.4	4.1	4.2	3.0																							
16100 (CH)	3.4	3.1	2.3	3.4	3.9	3.2	3.2																							
16130 (CH)	3.5	3.0	2.4	3.5	3.9	4.7	3.5																							
17100 (CH)	3.5	2.9	2.4	3.6	3.7	4.3	3.6																							
17130 (CH)	3.5	2.9	2.4	3.7	3.6	3.9	3.5																							
18100 (CH)	3.5	2.9	2.3	3.5	3.5	3.9	3.7																							
18130 (CH)	3.5	2.9	2.4	3.5	3.3	3.8	3.7																							
19100 (CH)	3.4	2.9	2.4	3.4	3.4	3.7	3.7																							
19130 (CH)	3.7	3.0	2.3	3.4	3.4	3.7	3.7																							
20100 (CH)	3.5	2.9	2.4	3.4	3.4	3.8	3.8																							
20130 (CH)	3.6	2.8	2.4	3.4	3.4	3.8	3.8																							
21100 (CH)	3.6	2.8	2.4	3.5	3.6	3.7	3.8																							
21130 (CH)	3.6	2.8	2.4	3.6	3.6	3.8	3.8																							
22100 (CH)	3.7	2.7	2.3	3.7	3.7	3.7	3.8																							
22130 (CH)	3.5	2.7	2.3	3.7	3.7	3.7	3.8																							
23100 (CH)	3.6	2.7	2.3	3.8	3.8	3.8	3.8																							
23130 (CH)	3.5	2.7	2.3	3.9	3.8	3.8	3.8																							
23100 (CH)	3.5	2.7	2.3	4.1	3.5	3.8	3.8																							
23130 (CH)	3.5	2.7	2.3	4.1	3.5	3.8	3.8																							

CLOUD LIQUID - TABLE FOR: MARCH 1979 - FORT SILL OK

HR. (CST)	DAY OF MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			
0:00	(CM)																																.00	.01	
0:30	(CM)																																	.01	.01
1:00	(CM)																																	.00	.01
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22:00	(CM)																																	.01	.01
22:30	(CM)																																	.01	.01
23:00	(CM)																																	.00	.01
23:30	(CM)																																	.00	.01

CLOUD LIQUID - TABLE FOR: APRIL 1979 - FORT SILL OK

HR (CST)	DAY OF MONTH							23	24	25	26	27	28	29	30
	1	2	3	4	5	6	7								
0:00	(CM)	.02	.01	.00	.01	.00	.01	.00	.01	.00	.00	.00	.01	.00	0.00
0:30	(CM)	.02	.01	.00	.01	.00	.01	.00	.01	.00	.00	.00	.01	.00	0.00
1:00	(CM)	.01	.01	.00	.01	.00	.01	.00	.01	.00	.00	.00	.01	.00	0.00
1:30	(CM)	.16	.01	.00	.01	.00	.01	.00	.01	.00	.00	.00	.01	.00	0.00
2:00	(CM)	.06	.01	.00	.01	.00	.01	.00	.01	.00	.00	.00	.01	.00	0.00
2:30	(CM)	.03	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
3:00	(CM)	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
3:30	(CM)	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
4:00	(CM)	.01	.01	.03	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
4:30	(CM)	.01	.01	.06	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
5:00	(CM)	.00	.01	.11	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
5:30	(CM)	.00	.01	.12	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
6:00	(CM)	.00	.01	.09	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
6:30	(CM)	.01	.01	.43	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
7:00	(CM)	.01	.01	.09	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
7:30	(CM)	.01	.01	.10	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
8:00	(CM)	.01	.01	.15	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
8:30	(CM)	.01	.04	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
9:00	(CM)	.01	.05	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
10:00	(CM)	.02	.07	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
10:30	(CM)	.01	.04	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
11:00	(CM)	.01	.09	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
11:30	(CM)	.00	.10	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
12:00	(CM)	.00	.01	.05	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
12:30	(CM)	.00	.00	.04	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
13:00	(CM)	.00	.00	.07	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
13:30	(CM)	.01	.00	.06	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
14:00	(CM)	.01	.00	.04	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
14:30	(CM)	.01	.00	.06	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
15:00	(CM)	.01	.00	.03	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
15:30	(CM)	.01	.00	.05	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
16:00	(CM)	.01	.01	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
16:30	(CM)	.01	.00	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
17:00	(CM)	.01	.00	.03	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
17:30	(CM)	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
18:00	(CM)	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
18:30	(CM)	.02	.01	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
19:00	(CM)	.01	.01	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
19:30	(CM)	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
20:00	(CM)	.01	.00	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
20:30	(CM)	.01	.00	.03	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
21:00	(CM)	.01	.00	.03	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
21:30	(CM)	.01	.00	.04	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
22:00	(CM)	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
22:30	(CM)	.01	.00	.04	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
23:00	(CM)	.01	.00	.04	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00
23:30	(CM)	.01	.01	.03	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	0.00

CLOUD LIQUID - TABLE FOR: JUNE 1979 - FORT SILL OK

HR (CST)	DAY OF MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0000	(CH)			.00	.00	.02	.01	-.00																							
0130	(CH)		.13	.00	.00	-.00	.01	-.00																							
1430	(CH)		.03	.00	.00	.00	.01	-.00																							
1730	(CH)		.11	.00	.00	.00	0.00	-.00	-.00																						
2030	(CH)		.09	.00	.00	.00	-.01	0.00	-.00																						
2330	(CH)		.05	.00	.00	.00	.01	0.00	.01																						
3030	(CH)		.08	.00	.00	.00	-.01	0.00																							
3330	(CH)		.03	.00	.00	.00	.01	.01																							
4030	(CH)		.01	.00	.00	.00	.01	0.00																							
4330	(CH)		.01	.00	.00	.00	.01	0.00																							
5030	(CH)		.18	.00	.00	.00	.05	0.00																							
5330	(CH)		.12	.00	.00	.00	.03	0.00																							
6030	(CH)		.08	.00	.00	.00	.03	0.00																							
6330	(CH)		.08	.00	.00	.00	.00	.01																							
7030	(CH)		.08	.00	.00	.00	-.00	.01																							
7330	(CH)		.08	.00	.00	.00	.01	0.00																							
8030	(CH)		.10	.00	.00	.00	.05	0.00																							
8330	(CH)		.05	.00	.00	.00	.02	0.00	-.00																						
9030	(CH)		.01	.00	.00	.00	.10	0.00	-.00																						
9330	(CH)		.02	.00	.00	.00	0.00	-.00																							
10000	(CH)		.00	.00	.00	.00	0.00	-.00																							
10330	(CH)		.00	.00	.00	.00	.02	-.00																							
11000	(CH)		-.00	.00	.00	.00	0.00	-.00																							
11330	(CH)		0.00	-.00	.01	.00	0.00	-.00																							
12000	(CH)		0.00	.00	.00	.00	0.00	-.00																							
12330	(CH)		0.00	.00	.00	.00	0.00	-.00																							
13000	(CH)		0.00	.00	.00	.00	0.00	-.00																							
13330	(CH)		.01	.00	.00	.00	.00	-.00																							
14000	(CH)		.00	.00	.00	.00	.00	-.00																							
14330	(CH)		.01	.00	.00	.00	.10	0.00	-.00																						
15000	(CH)		.01	.00	.00	.00	.05	0.00	-.00																						
15330	(CH)		.00	.00	.00	.00	.12	0.00	-.00																						
16000	(CH)		.00	.00	.00	.00	.07	0.00	-.00																						
16330	(CH)		.00	.00	.00	.01	.06	.13	-.00																						
17000	(CH)		.00	.00	.00	.00	.03	.01	-.00																						
17330	(CH)		.00	.00	.00	.00	.03	.01	-.00																						
18000	(CH)		.01	.00	.00	.00	.01	.03	-.00																						
18330	(CH)		.03	.00	.00	.00	.00	-.00	-.00																						
19000	(CH)		.06	.00	.00	.00	.01	-.00	-.00																						
19330	(CH)		.11	.00	.00	.00	.01	-.00	-.00																						
20000	(CH)		.01	.00	.00	.00	.01	-.00	-.00																						
20330	(CH)		.00	.00	.00	.00	.01	-.00	-.00																						
21000	(CH)		.03	.00	.00	.00	.00	-.00	-.00																						
21330	(CH)		.05	.00	.00	.00	.01	-.00	-.00																						
22000	(CH)		.02	.00	.00	.00	.01	-.00	-.00																						
22330	(CH)		.15	0.00	.00	.00	.01	-.00	-.00																						
23000	(CH)		.12	.00	.00	.00	.02	-.00	-.00																						
23330	(CH)		.20	.00	.00	.01	.02	-.00	-.00																						

Gap's in Microwave Radiometer measurements of Atmospheric Precipitable Water Vapor and Cloud Liquid at Fort Sill, OK for the measurement period starting 1800 CST 3/29/79 through 2145 CST 6/08/79.

Gap's resulting in loss of data exceeding two hours:

DATE	TIME (CST)	CAUSE
4/10/79	9:45-17:30	Power and/or Rain
4/17/79	15:00-19:30	Rain
5/20/79	14:30-17:00	Rain
5/20/79	21:45-24:00	Rain
5/21/79	7:45-	Computer failure
6/01/79	-11:30	" " continued
6/05/79	9:45-13:30	Rain
6/07/79	3:00- 8:30	Dew formed on Antenna Window
6/08/79	3:00- 8:30	Dew formed on Antenna Window

Periods where data was lost on magnetic recording media and was reinserted from 30 min. real-time computer print out. This data is slightly degraded since it does not contain the most recent calibration information:

DATE	TIME (CST)
4/03/79	10:30-16:30
4/09/79	0:00-10:00
4/30/79	0:00-15:30
5/08/79	0:00-15:45
5/18/79	0:00-16:00
6/01/79	11:30-14:00
6/06/79	0:00-16:30

Rainfall at Fort Sill OK for the Period May 10, 1979 -
 June 11, 1979. Listed by Periods of Approximate Constant
 Rain Rate.

DATE	PERIOD (CST)	TOTAL (mm)	RATE (mm/hr)
5/20/79	14: 55-15: 22	3	7
5/20/79	15: 22-15: 44	29	80
5/20/79	15: 44-16: 08	13	34
5/20/79	16: 08-17: 13	3	2
5/20/79	21: 55-00: 55	18	18
5/27/79	02: 30-02: 50	1	4
5/30/79	08: 25-08: 40	15	61
5/30/79	08: 40-09: 00	5	15
6/01/79	23: 20-00: 20	1	1
6/02/79	07: 00-07: 02	1	18
6/05/79	09: 40-10: 45	4	4
6/05/79	10: 45-13: 10	17	40
6/05/79	14: 40-15: 30	2	2
6/06/79	15: 55-16: 02	11	98
6/06/79	16: 02-16: 15	3	9
6/08/79	15: 10-15: 15	2	18
6/08/79	17: 55-18: 00	1	15
6/08/79	19: 00-19: 05	3	34
6/08/79	21: 50-22: 00	27	160
6/08/79	22: 00-23: 10	5	4
6/09/79	00: 30-01: 30	3	3
6/09/79	14: 30-14: 40	5	27
6/09/79	16: 20-16: 40	1	4

Vapor derived by integrating Radiosonde releases at the I-SEE-O Hall at Fort Sill, OK.

DATE	TIME CST	VAPOR cm	HEIGHT mb	TIME CST	VAPOR cm	HEIGHT mb
4/03/79	09:15	1.49	253			
4/04/79	08:30	0.50	566			
4/06/79	09:30	1.38	415			
4/09/79				14:05	0.82	426
4/10/79	08:30	1.83	525			
4/12/79	08:20	0.87	548			
4/13/79	08:46	0.78	596			
4/16/79	08:45	2.07	626			
4/18/79	08:20	3.11	587			
4/19/79	09:16	2.63	591	13:54	2.49	525
4/20/79	08:40	2.93	471	14:15	2.46	700
4/23/79	09:00	1.69	673	13:32	1.72	499
4/24/79	08:21	2.22	520	13:32	2.08	555
5/03/79	09:03	3.21	508	14:00	2.41	544
5/04/79	09:40	1.64	508			
5/07/79	08:56	2.02	557			
5/10/79	08:46	3.77	536	13:40	2.61	461
5/11/79	09:00*	1.60	467	13:55	1.61	535
5/14/79	08:45	1.67	461			
5/15/79	08:55	1.93	440			
5/16/79	08:50	2.62	239			
5/21/79	09:15	2.38	474	13:50	2.68	609
5/22/79	09:15	3.14	467	14:20	2.70	525
5/23/79	09:07	1.84	720			
5/24/79	09:00*	2.70	525	14:06	1.94	449

Vapor by integrating Radiosonde releases by the
75 th. Field Artillery Meteorology Group, Fort Sill OK.

DATE	TIME CST	VAPOR cm	HEIGHT mb	TIME CST	VAPOR cm	HEIGHT mb
3/29/79	05:58	2.19	377	09:45	2.17	393
3/30/79	06:03	1.30	379	08:35	1.00	400
4/02/79	06:12	1.12	649	10:02	0.90	388
4/03/79	05:45	1.75	386			
4/04/79				10:18	0.70	384
4/05/78				09:48	1.01	386
4/06/79	06:06	2.08	388			
4/09/79	06:05	0.84	400	08:59	0.69	400
4/10/79	05:54	1.80	400	10:03	1.61	400
4/11/79	05:57	1.26	400	10:00	0.95	400
4/12/79	06:47	0.93	400	10:06	0.95	400
4/13/79	06:01	0.96	400	09:51	0.73	400
4/16/79	05:55	2.01	400	10:50	1.89	400
4/17/79	06:00	2.46	400	10:03	2.68	400
4/18/79	06:00	2.67	400	10:02	2.89	400
4/19/79				09:21	2.68	389
4/20/79	06:14	2.44	400	10:10	2.61	400
4/23/79	06:59	1.85	400	10:00	1.73	504
4/24/79	06:36	2.16	400	10:29	2.22	400
4/25/79	05:59	1.48	400	09:54	1.39	400
4/26/79	06:00	1.56	400	10:02	1.33	400
4/27/79	06:40	2.20	400	09:59	1.98	400
5/01/79	04:48	2.86	390	08:48	2.25	388
5/02/79	04:45	3.46	365	08:54	2.67	378
5/03/79	05:00	2.99	390	08:48	2.72	372
5/04/79	04:48	1.66	373	08:54	1.56	382
5/07/79	04:14	1.57	381	09:13	1.16	537
5/08/79	04:48	2.01	400	09:06	1.83	379
5/09/79	03:58	2.02	441	08:51	2.18	378
5/10/79	05:05	3.36	405	09:00	2.90	400
5/11/79	04:54	1.72	385	09:02	1.44	400
5/14/79	04:47	1.44	400	08:50	0.97	400
5/15/79	04:42	1.21	400	09:11	1.18	400
5/16/79	07:02	1.14	400	09:13	1.40	400
5/17/79	04:55	1.43	400	09:14	1.41	400
5/18/79	05:11	2.99	400	08:44	2.78	400
5/21/79	06:10	2.78	381			
6/01/79	04:59	2.84	400	08:56	2.79	400
6/04/79	05:10	2.59	400	09:29	2.59	400
6/05/79	04:58	3.46	400	10:00	4.15	400
6/06/79	06:28	3.23	400	08:59	3.50	400
6/07/79	05:02	2.81	400	08:55	2.71	400
6/08/79	05:01	2.93	400			

Vapor by integrating Radiosonde releases at the National
Weather Services at Oklahoma City, OK.

DATE	TIME CST	VAPOR cm	HEIGHT mb	TIME CST	VAPOR cm	HEIGHT mb
3/29/79	06:00	2.23	100	18:00	1.52	100
3/30/79	06:00	1.12	250	18:00	1.20	379
3/31/79	06:00	0.93	100	18:00	1.63	172
4/01/79	06:00	1.88	100	18:00	1.16	100
4/02/79	06:00	0.69	100	18:00	0.95	100
4/03/79	06:00	1.54	127	18:00	1.15	194
4/04/79	06:00	0.55	100	18:00	0.61	100
4/05/79	06:00	0.96	100	18:00	1.26	100
4/06/79	06:00	1.37	100	18:00	1.49	100
4/07/79	06:00	1.35	100	18:00	2.23	100
4/08/79	06:00	1.83	100	18:00	0.79	100
4/09/79	06:00	0.66	100	18:00	1.04	111
4/10/79	06:00	1.62	100	18:00	3.21	282
4/11/79	06:00	1.25	100	18:00	0.93	100
4/12/79	06:00	0.71	100	18:00	1.21	100
4/13/79	06:00	0.95	100	18:00	0.85	100
4/14/79				18:00	1.45	100
4/15/79	06:00	1.39	100	18:00	2.01	100
4/16/79	06:00	1.77	100	18:00	1.89	100
4/17/79	06:00	2.28	100	18:00	2.10	100
4/18/79	06:00	3.38	100	18:00	2.89	100
4/19/79	06:00	2.88	100	18:00	2.69	100
4/20/79	06:00	2.42	100	18:00	2.70	100
4/21/79	06:00	2.31	100	18:00	1.35	100
4/22/79	06:00	2.12	100	18:00	2.15	100
4/23/79	06:00	2.21	100	18:00	1.82	100
4/24/79	06:00	2.23	100	18:00	2.21	100
4/25/79	06:00	2.04	111	18:00	1.76	100
4/26/79	06:00	1.53	100	18:00	0.98	100
4/27/79	06:00	1.78	100	18:00	1.21	100
4/28/79	06:00	0.99	100	18:00	1.99	100
4/29/79	06:00	1.14	100	18:00	1.34	100
4/30/79	06:00	1.01	100	18:00	1.77	100
5/01/79	06:00	2.37	100	18:00	2.78	100
5/02/79	06:00	3.21	100	18:00	2.69	100
5/03/79	06:00	2.94	100	18:00	3.07	115
5/04/79	06:00	2.09	100	18:00	1.44	100
5/05/79	06:00	0.77	100	18:00	1.17	100
5/06/79	06:00	1.48	100	18:00	1.28	100
5/07/79	06:00	1.30	100	18:00	1.98	100
5/08/79	06:00	1.58	100	18:00	2.35	100
5/09/79	06:00	1.70	225	18:00	2.58	100
5/10/79	06:00	3.33	458	18:00	2.43	100
5/11/79	06:00	1.49	100	18:00	1.86	100
5/12/79	06:00	1.00	100	18:00	1.30	100
5/13/79	06:00	1.44	100			
5/14/79	06:00	1.78	100	18:00	1.87	100
5/15/79	06:00	1.86	100	18:00	1.99	100
5/16/79	06:00	1.76	100	18:00	2.31	100
5/17/79	06:00	2.35	100	18:00	2.92	100
5/18/79	06:00	3.27	100	18:00	3.08	100
5/19/79	06:00	3.04	100	18:00	3.02	100
5/20/79	06:00	3.92	100	18:00	3.65	146
5/21/79	06:00	3.52	100	18:00	3.38	100
5/22/79	06:00	3.11	100			
5/31/79				18:00	2.65	100
6/01/79	06:00	3.35	130	18:00	3.42	100
6/02/79	06:00	3.67	100	18:00	3.24	217
6/03/79	06:00	2.80	100	18:00	1.98	100
6/04/79	06:00	2.39	100	18:00	2.94	100
6/05/79	06:00	4.03	100	18:00	3.98	100
6/06/79	06:00	3.21	100	18:00	4.76	369
6/07/79	06:00	3.54	100			

