NO. 193 WATER-VAPOR MEASURES, MT. LEMMON AREA

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ABSTRACT

Daytime atmospheric water-vapor measures were continued for Mt. Lemmon, the Catalina Observatory, and Tucson. As before (*LPL Comm. No. 158*), the three sets are closely related in terms of their altitude differences, with the average empirically-determined scale-height value, 2.3 km. During the Winter and Spring of 1971 observations were made for more than 90% of the days. The measures are listed in Tables I, II, and III, and are shown, reduced to Mt. Lemmon, in Figures 1 and 2. For comparison, Figures 3-6 show the 1969-70 data published in *LPL Communication No. 158*. The averages for the stations are shown in Figure 7.

The instrumental scale was checked in *LPL Communication No. 159* and confirmed below 2.2 mm; above this value a gradual departure set in, still uncertain beyond 3.0 mm. In this paper the calibration was continued to higher values by means of atmospheric radio-sonde data. Tables I-III and Figures 1-6 have been kept in the old scale (used in *LPL Comm. No. 158*); but the ordinates in the final Figure 7 have been adjusted to the readings of the radio-sonde data.

Section 3 interprets the nature of the fluctuations shown in Figure 7 in terms of air masses of different origins, identified with the aid of radio-sonde wind directions for the upper atmosphere derived locally, above the Tucson airport.

1. Introduction

This paper is a continuation of *LPL Communication No. 158* (containing H_2O measures made in 1969 and 1970), which in turn followed the more general study of astronomical high-altitude sites in *LPL Communications Nos. 142, 156,* and *157; No. 157* dealt with the medical problems. The present paper together with *No. 158* cover a fairly representative set of data for the *annual* run of H_2O values and its short-period *variations* above Mt. Lemmon. One more set of data, taken in 1971-72, will be published separately.

2. The Measures

The measures here presented were made with the solar-beam H_2O meter, developed and lent for this purpose by Dr. Frank Low. Its calibration was tested in *LPL Communication No. 159*, where Dr. Low's original calibrations were found confirmed up to 2.2 mm H_2O, at which point a small deviation began up to 3 mm H_2O. Beyond 3 mm no verification was possible with the new data. In this paper the calibration is extended to higher H_2O readings with the use of radio-sonde data taken at the Tucson International Airport that measure the atmospheric water-vapor profile from 920-7 mb. It is found that the tabular readings above 3 mm must be corrected upward, as was suspected in *LPL Communication No. 159*, p. 398, while the lower values are again confirmed (most past uses of the instrument have been concerned with low and very low readings).

The most practical way to carry out this program appeared to be to present the 1971 data by listing in Tables I, II, and III, the "tabular" H_2O readings in the same manner as was done in *LPL Communication No. 158* for 1969 and 1970; then plot the 1971 results (Figs. 1 and 2) as well as the published 1969-70 values (Figs. 3-6); and combine the data from the three observing stations into a single set of graphs (Fig. 7). Representative maxima and minima of this graph were then compared with the H_2O contents above Mt. Lemmon based on the free-atmosphere radio-sonde data for those times; the radio-sonde abundances reduced to "equivalent" H_2O absorptions with allowance for the mean pressure for the H_2O in the atmosphere above Mt. Lemmon, 600 mb (cf. *LPL Comm. No. 158*, p. 394); whereupon the scale correction was derived for the higher readings and applied to the ordinates of Figure 7.

At the other extreme, the lowest readings of the radio-sonde calibration give only an *upper limit*. On dry nights the *reported* relative humidities are usually 14%, which is the recording limit of the equipment; some values may be considerably less (comments on "motor boating" of the airborne humidity equipment were made in *LPL Communication No. 142*, p. 126).

As in *LPL Communication No. 158*, Table I lists the measures made from the roof of the Space Sciences Building in Tucson; Table II, measures made at the Mt. Lemmon solar observatory (60 feet below the summit); and Table III, measures made at the Catalina Observatory. The equivalent values for Mt. Lemmon given in Tables I and III are computed from the preceding columns, allowing for the elevation differences.

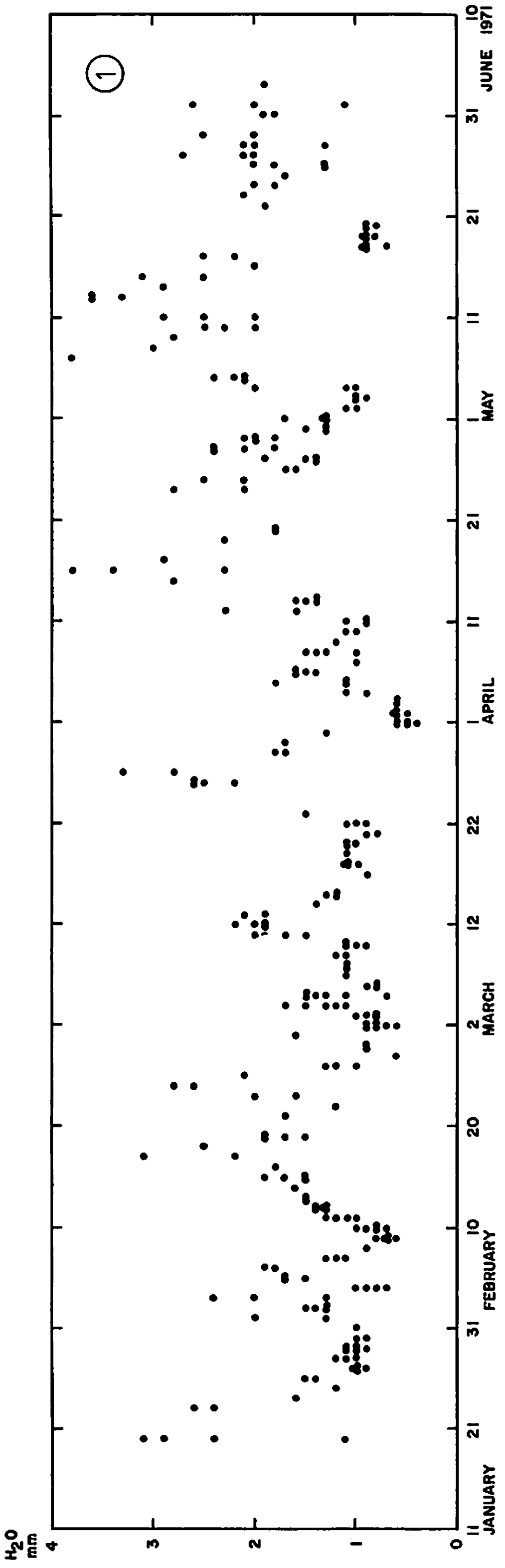


Figure 1 Tucson daytime H_2O measures reduced to Mt. Lemmon

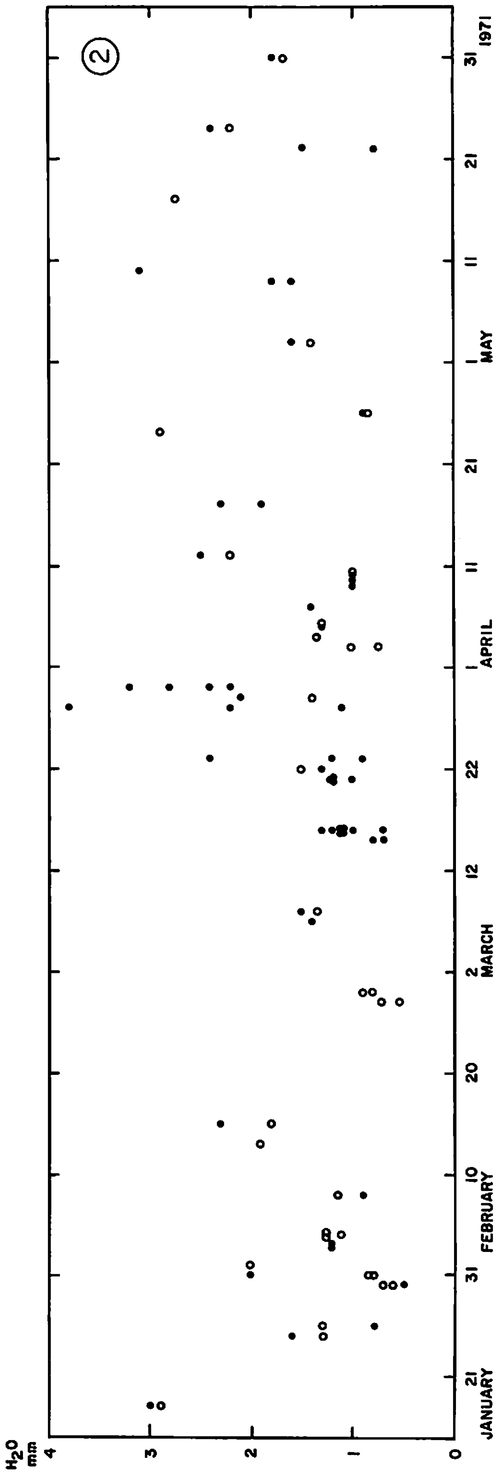


Figure 2 Mt. Lemmon daytime H_2O measures (dots) and Catalina (circles)

Figure 3 Tucson daytime H_2O measures reduced to Mt. Lemmon. Precedes Fig. 1

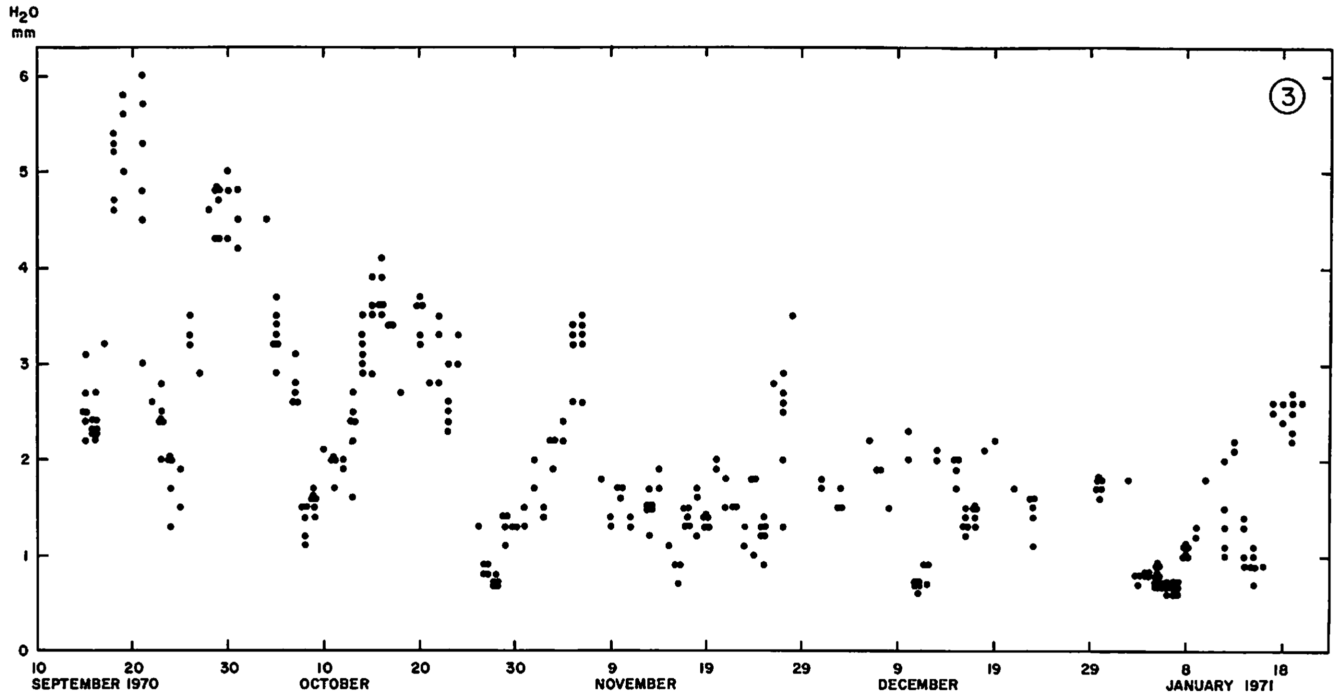
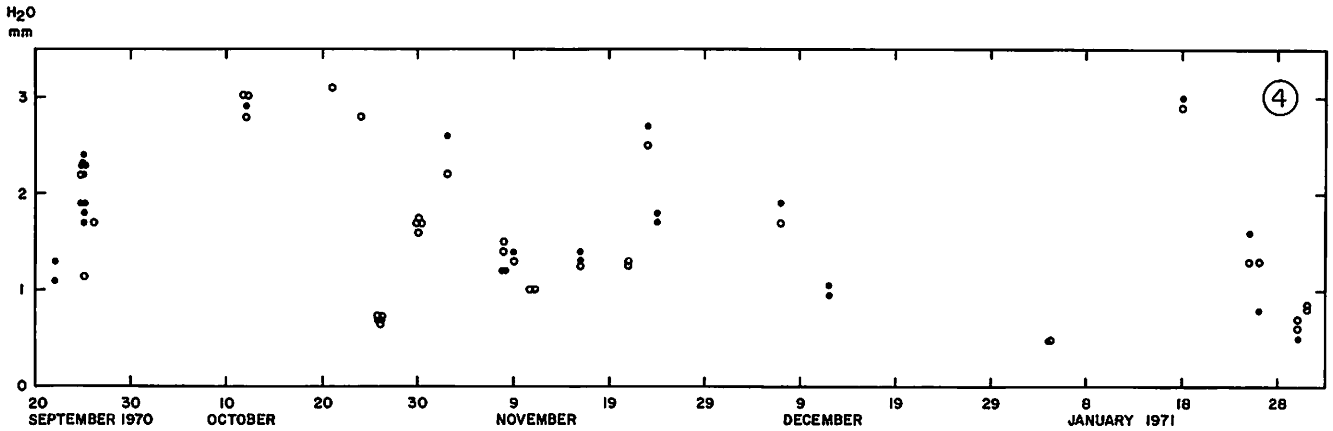


Figure 4 Mt. Lemmon daytime H_2O measures (dots) and Catalina (circles). Cf. Fig. 2



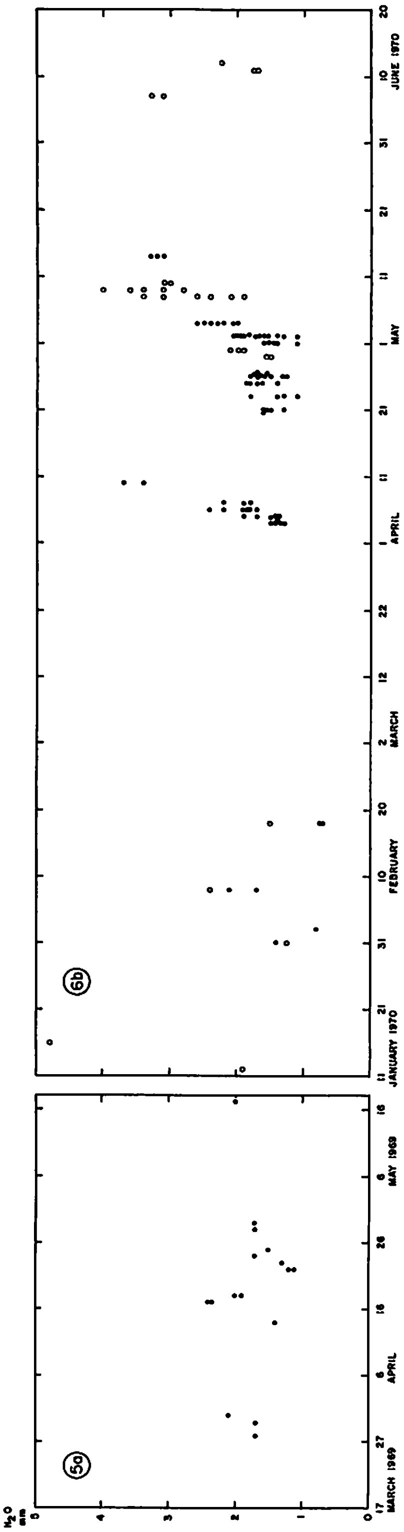


Figure 5 Tucson H_2O measures reduced to Mt. Lemmon. Cf. Figs. 1, 3

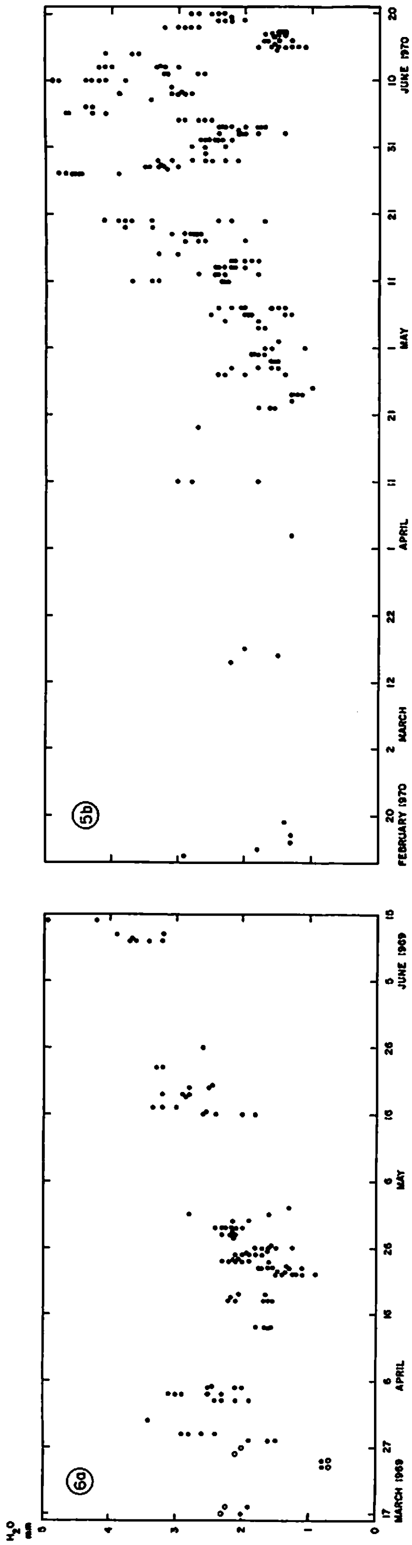


Figure 6 Mt. Lemmon daytime H_2O measures (dots) and Catalina (circles). Cf. Figs. 2, 4

The same scale height derived before, 2.27 km, was adopted in these reductions. (This scale height was derived *empirically* and thus compensates for minor scale errors).

Figure 1 shows the entries of the last column of Table I. Figure 2 combines the values of Tables II and III. The measures made in Tucson are nearly complete for all clear days during the interval, with the workload divided between the two authors. It is seen that measures were made on more than 90% of the days.

The figures show with unexpected clarity almost cyclic variations in the water-vapor content. These must be due to an alternation between air masses over Southern Arizona. The vertical spread of the dots for a given day is due in part to orographic effects. For this reason we average in Figure 7 the combined evidence of the Mt. Lemmon-Catalina data (Figs. 2, 4, 6) with the data derived in Tucson (Figs. 1, 3, 5), to obtain the day-to-day absorption variations.

Ideally, a graph similar to Figure 7 should be constructed showing the variation of the H_2O content over Mt. Lemmon based on the radio-sonde information (available on microfilms). Because of the considerable labor involved, we have limited here the comparison to the major minima and maxima. The correspondence between the two sets of data is quite good, with the minima and maxima readily identifiable in the microfilm records. The approximate levels below 1.5 mm were confirmed (for zenith objects the limit would be about 2.5 mm). For higher readings, we have corrected in Figure 7 the scale to correspond to the radio-sonde data.

3. Discussion

The data here presented are daytime measures. However, it has been our experience that the measured H_2O absorption in the solar beam on Mt. Lemmon is not minimal at noon (shortest airpath), but at 9 or 10 AM, and again around 3 PM. This appears due to the fact that the daytime solar exposure of the mountain causes updrafts which carry the higher H_2O mixing ratios from lower levels upward. Also, when the mountain is snow-covered (approx. 4-5 months of the year), the daytime evaporation causes the atmospheric boundary layer to contain more moisture than at night when the temperatures are lower. Nighttime observations have indicated that the water-vapor values sometimes drop down to 0.2-0.3 mm, a fact already suggested by the frequency curve of H_2O amounts above Mt. Lemmon published in *LPL Communication No. 156*, Fig. 25 (p. 363), and *No. 142*, Fig. 10 (p. 135). Even daytime values may be very low; we have witnessed solar observations at 20μ made with the University of Minnesota telescope, which found negligible extinctions for solar altitudes as low as 10-15°. A program is under consideration for regular nighttime observations using the 1.4μ H_2O band.

Attention is called to *LPL Communication No. 156* for the thermograph and relative-humidity records obtained at both the Mt. Lemmon and the Catalina Observatories for the period Oct. 26, 1970-Jan. 25, 1971, part of the interval covered by the integrated H_2O measures. It is seen that periods of very low relative humidity (5-20%) occur. In the radio-sonde data values of 14% (the lowest recordable value) are quite common at 700 mb and above.

The radio-sonde data also include the *wind direction* and *speed*, *temperature*, and *barometric pressure*, for all altitudes from 920-7 mb (Mt. Lemmon averages 720 mb). Correlation of these data with the occurrence of the maxima and minima

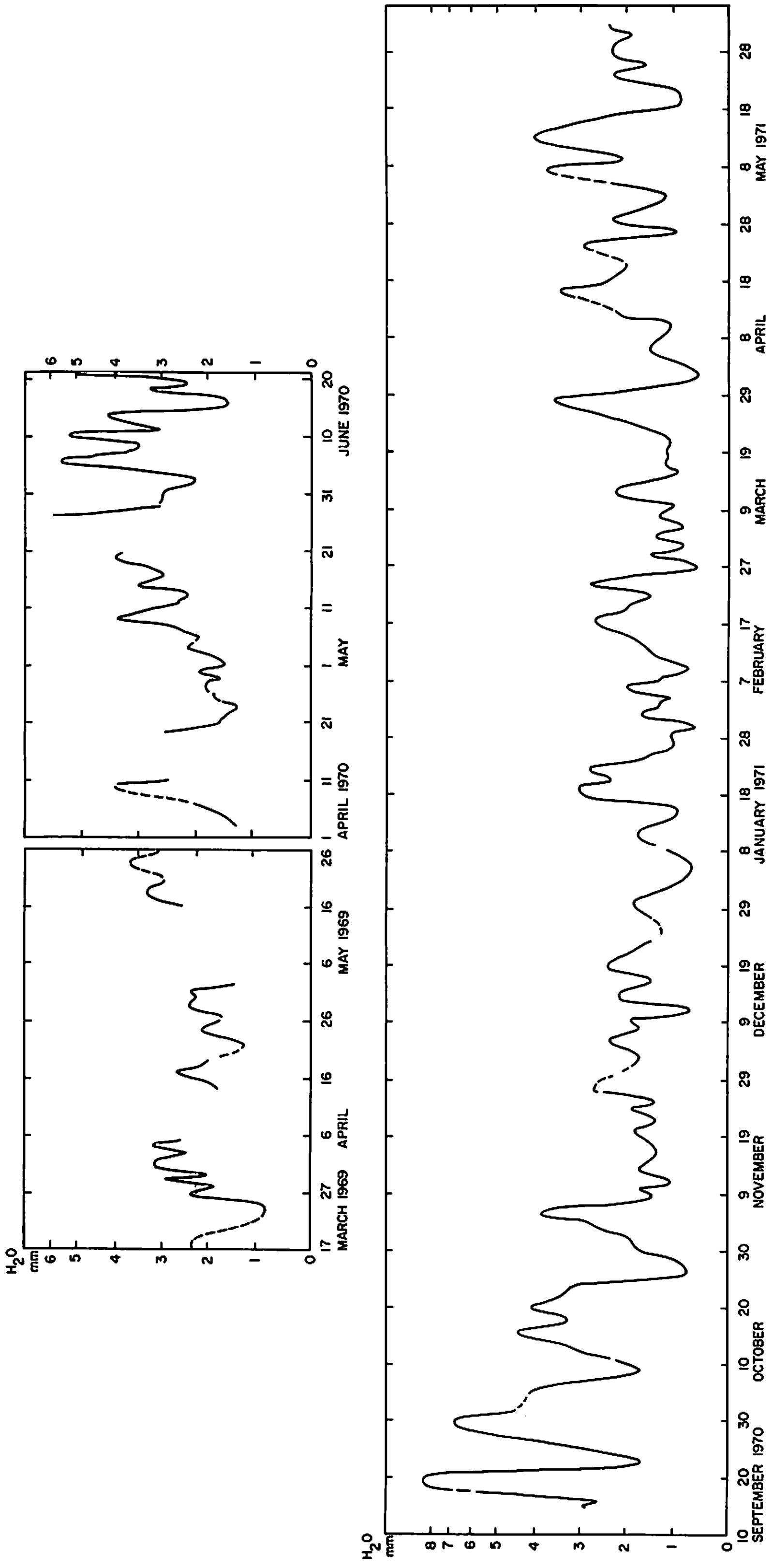


Figure 7 Combined results of daytime Mt. Lemmon H_2O data, with ordinates adjusted to Tucson Airport radio-sonde data

in Figure 7 has led to the following preliminary conclusions: (a) the normal air flow on Mt. Lemmon is from the West, so that the air mass is normally Pacific in origin; (b) the exceptions are the period of the monsoon, mid- or late-June till mid- or late-September, when more humid air masses move in from the Gulf of Mexico (SE wind); the alternation shown in Figure 7, September 1970, is due to the departing monsoon, with incursions of Pacific air causing drier periods. Similar alternations occur in June and sometimes throughout the Summer; (c) in mid-Winter and Spring North-Continental air masses move in, causing at times periods of very low humidity to follow snow falls; (d) the moisture content of the Pacific air masses varies, depending on barometric pressure. Barometric highs often persist over the Continental Southwest, for one or more weeks at a time, throughout the Fall, Winter, and Spring, which cause *subsidence of upper-atmospheric air* of low moisture content (down to 3-15% relative humidity). Samples of such air masses were recorded during the same interval in *LPL Communication No. 156*, pp. 364-366. Local subsidence, due to nighttime cooling of the summit, may cause a further lowering of the humidity. On the whole, however, the free-air values, measured by radio-sonde, are good approximations of the actual conditions found over Mt. Lemmon, an experience in common with a few other mountain sites similarly explored. While most often the vertical H_2O profile of the atmosphere is quite smooth and monotonic, exceptions (moist layers) do occur, so that surface humidity data are no reliable substitute for integrated measures (solar beam or stellar observations).

Acknowledgment: This work was done as part of the Laboratory's continuing infrared programs, assisted by NASA Grant NGL 03-002-002.

TABLE I - Tucson, Space Sciences Bldg., 2510 ft (765 m), roof or surface(s)

Date	MST	H_2O(Sun)	H_2O(Zenith)	Mt.L.*
1971				
Jan 20	12:00	12.5	7.6	3.1
	13:56	12.8	7.2	2.9
	16:14	22.9	5.9	2.4
	17:10	29.3	2.8	1.1
23	10:50	10.8	5.9	2.4
	11:47	10.5	6.5	2.6
24	13:31	6.4	3.9	1.6
25	8:57	10.0	2.9	1.2
26	8:13	22.9	3.8	1.5
	12:45	5.5	3.5 s	1.4
27	9:26	6.5	2.4	1.0
	11:05	4.3	2.5	1.0
	13:37	4.0	2.4	1.0
	17:06	15.6	2.2	0.9
28	9:17	6.6	2.4	1.0
	10:45	4.7	2.6	1.1
	11:58	4.5	2.9	1.2
29	8:53	8.7	2.5	1.0
	11:00	4.9	2.8	1.1
	14:01	4.4	2.6	1.1
	15:57	7.3	2.5	1.0
	16:57	13.0	2.3	0.9
30	10:22	4.7	2.5	1.0
	11:55	3.6	2.3	0.9
31	9:43	5.7	2.4 s	1.0
Feb 1	9:08	9.1	3.1	1.3
	10:26	9.1	4.8	2.0
2	9:12	10.0	3.5	1.4
	11:05	6.0	3.6	1.5
	11:58	5.1	3.3	1.3
	15:18	6.9	3.2	1.3
3	9:05	14.6	5.0	2.0
	10:09	11.7	5.9	2.4
	14:23	5.7	3.3	1.3
4	9.03	5.2	1.8	0.7
	9:35	4.5	1.9	0.8
	15:46	6.1	2.5	1.0
	17:31	24.0	2.1	0.9
5	9:03	10.9	3.7	1.5
	11:13	6.5	4.1	1.7
	11:55	6.3	4.2	1.7
6	10:28	8.5	4.7	1.9
	11:51	7.1	4.7	1.9
	14:09	7.3	4.4	1.8
7	11:26	5.0	3.2 s	1.3
	12:23	4.4	2.9 s	1.2
	14:06	4.5	2.8 s	1.1
8	10:58	3.7	2.3	0.9
9	9:09	4.6	1.7	0.7
	11:08	3.1	1.9	0.8
	12:00	2.7	1.8	0.7
	14:54	3.2	1.7	0.7
	16:34	5.2	1.5	0.6
10	9:07	4.9	1.8	0.7
	10:38	3.3	1.9	0.8
	11:58	3.0	2.0	0.8
	14:05	3.4	2.1	0.9
	16:11	6.8	2.4	1.0
11	9:06	9.0	3.2	1.3
	11:16	4.6	3.0	1.2
	13:48	3.9	2.5	1.0
	15:52	6.2	2.6	1.1
12	9:17	7.4	3.1	1.3
	10:59	5.1	3.2	1.3
	12:02	5.0	3.5	1.4
	14:25	5.8	3.5	1.4
	17:03	15.3	3.1	1.3
13	10:30	6.1	3.6	1.5
	11:58	5.3	3.7	1.5
14	12:09	5.7	4.0	1.6
15	9:05	9.6	3.7	1.5
	10:11	7.0	3.8	1.5
	15:55	11.1	4.7	1.9
	16:58	17.7	4.1	1.7
16	9:18	10.6	4.5	1.8
17	11:57	7.7	5.5	2.2
	14:07	11.6	7.6	3.1
18	16:16	16.5	6.1	2.5
19	9:02	11.9	4.7	1.9
	11:55	5.7	4.1	1.7
	13:50	6.8	4.7	1.9
	16:54	14.1	3.6	1.5
21	13:02	5.8	4.2	1.7
22	9:17	6.7	3.0	1.2
23	9:15	8.7	3.9	1.6
	12:07	6.7	4.9	2.0
24	9:55	12.3	6.8	2.8
	15:39	12.6	6.3	2.6
25	12:05	6.8	5.1	2.1
26	10:00	5.4	3.1	1.3
	11:45	4.0	3.0	1.2
	15:59	5.5	2.4	1.0
27	11:33	1.9	1.4	0.6
28	10:10	3.5	2.1	0.9
	11:36	3.0	2.2	0.9
Mar 1	10:32	6.0	3.9	1.6
2	8:58	3.6	1.6	0.7
	9:01	3.3	1.4	0.6
	10:58	2.7	1.9	0.8
	11:59	2.7	2.1	0.9
	15:58	4.0	2.1	0.9
	17:24	10.3	2.0	0.8

Date	MST	H_2O(Sun)	H_2O(Zenith)	Mt.L.*
1971				
Mar 3	9:38	3.7	2.0	0.8
	10:52	3.1	2.2	0.9
	12:10	2.6	2.0	0.8
	13:54	3.3	2.4	1.0
4	9:25	5.4	2.7	1.1
	10:51	4.1	2.9	1.2
	13:18	5.4	4.2	1.7
	15:18	6.4	3.7	1.5
	16:51	10.4	3.2	1.3
5	9:07	7.4	3.4	1.4
	10:34	5.3	3.6	1.5
	11:51	4.6	3.6	1.5
	13:55	4.4	3.2	1.3
	15:36	5.0	2.7	1.1
	16:49	5.5	1.8	0.7
6	9:34	3.6	2.0	0.8
	10:35	3.2	2.2	0.9
	11:46	2.6	2.0	0.8
7	12:10	3.4	2.7	1.1
8	8:57	5.9	2.7	1.1
	17:07	10.0	2.7	1.1
9	8:57	6.2	2.8	1.1
	11:36	3.7	2.9	1.2
10	8:58	4.9	2.3	0.9
	10:44	3.4	2.4	1.0
	15:01	4.4	2.8	1.1
	17:12	10.2	2.6	1.1
11	9:06	7.8	3.8	1.5
	10:50	6.3	4.6	1.9
	11:57	5.4	4.3	1.7
	14:06	6.7	5.0	2.0
12	8:59	9.7	4.6	1.9
	13:05	6.6	5.3	2.2
	15:09	7.7	4.8	2.0
	16:54	14.1	4.6	1.9
13	10:20	6.9	4.7	1.9
	12:37	6.4	5.2	2.1
14	11:50	4.4	3.5	1.4
15	9:16	5.9	3.2	1.3
	11:58	3.7	3.0	1.2
	12:55	3.6	3.0	1.2
17	17:06	7.2	2.1	0.9
18	9:06	5.2	2.7	1.1
	10:49	3.7	2.8	1.1
	11:55	3.4	2.8	1.1
	14:49	3.4	2.3 s	1.0
19	13:28	3.5	2.8	1.1
20	9:32	4.7	2.8	1.1
	10:42	3.3	2.5	1.0
	12:32	3.3	2.8	1.1
21	8:26	5.2	2.1	0.9
	16:02	3.8	1.9 s	0.8
22	9:38	4.0	2.5	1.0
	10:22	3.6	2.6	1.1
	17:23	9.4	2.3	0.9
23	10:39	4.8	3.6	1.5
26	9:44	9.2	6.1	2.5
	11:54	7.3 s	6.3	2.6
	14:11	8.2	6.4	2.6
	16:56	15.5	5.5	2.2
27	10:44	8.7	6.9	2.8
	14:30	10.9	8.2	3.3
29	9:35	6.2 s	4.1	1.7
	17:22	16.8	4.5	1.8
30	17:08	13.2	4.2 s	1.7
31	17:21	11.2	3.1	1.3
Apr 1	8:58	2.0	1.1	0.4
	10:23	1.5	1.1 s	0.5
	12:15	1.7	1.5	0.6
	13:48	1.7	1.4	0.6
	15:29	1.9	1.2	0.5
2	9:00	2.3	1.3	0.5
	11:18	1.7	1.4	0.6
	13:16	1.7	1.5	0.6
	17:06	4.1	1.4	0.6
3	10:13	1.9	1.4	0.6
	11:36	1.7	1.5	0.6
4	13:30	3.2	2.8	1.1
	16:38	5.2	2.3	0.9
5	9:04	4.7	2.8	1.1
	10:57	5.4	4.5	1.8
	17:01	7.1 s	2.6	1.1
6	9:05	5.7	3.4	1.4
	11:30	4.2	3.7	1.5
	13:23	4.6	4.0	1.6
	14:56	5.6	4.0 s	1.6s
7	17:12	7.3	2.4	1.0
8	8:59	4.1	2.4	1.0
	11:41	3.4	3.0	1.4
	14:12	4.7	3.8	1.5
	16:52	7.9	3.1	1.3
9	14:03	3.6	3.0	1.2
10	10:53	3.1	2.6	1.1
	11:16	2.7	2.4	1.0
11	10:19	2.6	2.0 s	0.9
	12:01	2.3	2.1	0.9
	16:20	5.1 s	2.6 s	1.1
12	10:17	4.9	3.9	1.6
	16:37	12.6	5.7	2.3
13	9:01	5.7	3.5	1.4
	11:52	3.8	3.5	1.4
	14:22	4.5	3.6	1.5
	17:00	10.3	3.9	1.6

Date	MST	H_2O(Sun)	H_2O(Zenith)	Mt.L.*
1971				
Apr 15	15:42	11.1	7.0	2.8
16	9:01	13.4	8.4	3.4
	12:36	10.2	9.4	3.8
	17:49	27.1	5.7	2.3
17	10:12	8.8	7.1	2.9
19	9:36	7.2	5.2	2.1
	10:30	6.8	5.7	2.3
20	9:17	6.4	4.4	1.8
	10:41	5.3	4.5	1.8
24	9:10	7.7	5.2	2.1
	11:28	7.5	6.9	2.8
25	12:45	5.5	5.2	2.1
	14:46	7.7	6.1	2.5
26	9:02	6.4	4.2	1.7
	10:09	4.9	4.0	1.6
27	9:08	5.0	3.4	1.4
	11:33	3.7	3.4 s	1.4
	14:05	5.3	4.6	1.9
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	12:44	6.2	5.9	2.4
	17:04	12.7	5.1	2.1
29	8:57	7.4	4.8	2.0
	10:57	5.4	4.9	2.0
	14:03	6.0	5.2	2.1
	16:38	9.0	4.4	1.8
30	9:00	5.4	3.6	1.5
	10:59	3.5	3.2	1.3
	13:45	3.5	3.1	1.3
May 1	10:11	3.8	3.2	1.3
	13:27	3.6	3.3	1.3
	15:24	6.0	4.2	1.7
	17:01	7.9	3.3	1.3
2	11:06	3.1	2.8	1.1
	17:31	7.7	2.5	1.0
3	9:01	3.6	2.4	1.0
	10:29	2.8	2.4	1.0
	18:04	10.2	2.1	0.9
4	9:00	5.7	3.9	1.6
	11:47	5.3	5.0 s	2.0
	16:51	8.0	3.6	1.5
5	9:11	7.4	5.2	2.1
	11:19	6.4	6.0	2.4
	13:23	5.8	5.4	2.2
	17:58	22.3	5.1	2.1
7	11:34	9.8	9.3	3.8
8	15:26	10.4	7.5	3.0
9	11:27	7.1	6.8	2.8
10	9:35	7.3	5.7	2.3
	10:14	7.1 s	6.1	2.5
	17:21	13.9	5.0	2.0
11	8:59	7.1	4.8	2.0
	11:44	7.5	7.2	2.9
	15:39	9.0	6.1	2.5
13	9:00	12.7	8.8	3.6
	11:22	9.4	8.9	3.3
	14:29	9.5	8.0	3.3
14	15:33	10.4	7.2	2.9
15	9:40	7.9	6.2	2.5
	12:39	7.9	7.6 s	3.1
16	16:19	8.5	4.9	2.0
17	9:07	8.4	5.3	2.2
	10:14	7.1	6.1	2.5
18	9:11	2.9	2.1	0.9
	11:05	2.5	2.3	0.9
	13:06	2.4	2.3	0.9
	17:04	4.2	1.8	0.7
19	9:03	3.0	2.1	0.9
	12:01	2.1	2.0	0.8
	14.55	2.7	2.1 s	0.9
	17:17	5.4	2.1	0.9
20	9:27	2.7	2.1	0.9
	11:44	2.1	2.0	0.8
	14:40	2.8	2.3	0.9
22	11:06	4.9	4.6	1.9
23	11:00	5.5 s	5.1	2.1
24	9:11	6.7	4.9	2.0
	10:18	5.1	4.4 s	1.8
25	9:00	5.8 s	4.1	1.7
26	9:02	6.9	4.9	2.0
	10:59	4.8	4.5	1.8
	15:01	4.2	3.3	1.3
	17:30	9.0	3.2	1.3
27	9:07	7.1	5.1	2.1
	11:31	5.1	4.9	2.0
	14:35	8.0	6.7	2.7
28	9:27	6.5	5.0	2.0
	12:41	5.2	5.1	2.1
	15:55	4.8	3.2	1.3
29	9:52	5.9	4.9	2.0
	15:15	8.0	6.2	2.5
31	9:13	6.1	4.5	1.8
	10:36	5.2	4.7	1.9
Jun 1	12:59	6.6	6.5	2.6
	14:34	5.8	4.9	2.0
	16:22	4.6	2.7	1.1
3	8:29	7.4	4.6	1.9

* Computed from preceding column with known average scale height.

TABLE II - Mt. Lemmon Solar Obs. 9100 ft (2770 m)

Date	MST	H_2O(Sun)	H_2O(Zenith)
1971			
Feb 1	14:40	3.7	2.0
4	12:53	1.8	1.2
	12:59	1.8	1.2
8	15:00	1.8	0.95
15	13:30	3.3	2.3
Mar 7	16:56	4.6	1.4
8	14:25	2.2	1.55
15	15:35	1.4	0.8
	16:23	1.7	0.7
16	9:47	1.2	0.7
	11:54	1.3	1.05
	12:42	1.4	1.15
	12:47	1.4	1.15
	13:31	1.6	1.3
	14:44	1.8	1.2
	16:00	2.3	1.1
	16:41	2.9	1.1
21	10:31	1.6	1.2
	11:40	1.5	1.2
	12:39	1.4	1.2
	13:52	1.3	1.0
22	14:31	1.7	1.3
23	13:14	2.9	2.4
	16:00	1.8	0.9
	17:34	5.6	1.2
28	11:13	4.6	3.8
	14:15	2.8	2.2
	17:09	3.5	1.1
29	13:50	2.6	2.1
30	10:10	3.3	2.4
	11:33	3.8	3.25
	12:34	3.2	2.8
	13:37	2.7	2.25
Apr 5	14:40	1.7	1.3
7	14:56	1.9	1.4
9	11:40	1.1	1.0
10	14:23	1.3	1.0
	15:26	1.5	1.0
12	14:05	3.0	2.5
17	15:11	2.6	1.9
	15:50	3.7	2.3
26	14:25	1.1	0.9
May 3	14:35	1.9	1.6
9	15:26	2.5	1.8
	16:18	2.8	1.6
10	14:25	3.6	3.1
22	12:57	0.8	0.8
	14:23	1.8	1.55
24	14:25	2.8	2.4
31	15:30	2.45	1.8

Table III - Catalina Observatory, Site I (8270 ft - 2520 m)

Date	MST	H_2O(Sun)	H_2O(Zenith)	Mt.Lemmon*
1971				
Feb 1	13:15	3.5	2.3	2.0
4	11:45	1.9	1.2	1.1
	12:13	2.1	1.4	1.25
	13:29	2.2	1.4	1.25
8	13:50	2.0	1.3	1.15
13	14:45	3.6	2.1	1.9
15	12:17	2.8	2.0	1.8
27	13:41	1.1	0.8	0.7
	15:46	1.3	0.6	0.53
28	13:53	1.3	0.9	0.8
	17:05	3.9	1.0	0.9
Mar 8	12:55	1.9	1.5	1.35
22	12:50	2.0	1.7	1.5
29	12:07	1.8	1.6	1.4
Apr 3	14:58	1.6	1.1	1.0
	16:16	1.7	0.85	0.75
4	11:20	1.7	1.5	1.35
5	13:20	2.3	2.0	1.8
10	17:00	3.0	1.15	1.0
12	12:45	2.7	2.5	2.2
24	15:25	4.7	3.3	2.9
26	12:08	1.0	0.95	0.85
May 3	13:15	1.75	1.6	1.4
17	12:35	3.2	3.1	2.75
24	12:25	2.5	2.45	2.2
31	13:45	2.0	1.9	1.7

* Computed from preceding column with known average scale height.