No. 170 PRELIMINARY REPORT ON OPTICAL SEEING TESTS AT MT. LEMMON, MARCH-JUNE 1971

by GEORGE V. COYNE, S.J.

August 1, 1971

ABSTRACT

One of the Lick Observatory Polaris telescopes was used to test seeing conditions at Mt. Lemmon. The preliminary results indicate that the seeing is not unlike that at Kitt Peak. Soundings of the air flow patterns across Mt. Lemmon under winter conditions were also made by flying smoke pots on tethered balloons to elevations of 500 feet. There does not appear to be any serious local turbulence.

As part of the preliminary development of the Mt. Lemmon Observatory, an optical seeing test program was begun with one of the six-inch Polaris telescopes used by Lick Observatory under the direction of Dr. Merle Walker for the testing of various prospective observing sites. The description of this instrument is given by Harlan and Walker (1965) and the results of tests made at various California sites (Walker, 1970) and at sites in Arizona, Baja California, Chile and Australia (Walker, 1971) have been published.

The test telescope, which had been most recently used at Kitt Peak, was obtained by us in January, 1971. It was mounted by Frecker and Arthur at Mt. Lemmon on the radar drum proposed as the site of the photopolarimetric 70-inch telescope (see Figure 22 of Kuiper, 1970). The telescope was first mounted on the catwalk at the west of the drum but vibrations were too severe there and it was moved to the north edge of the drum where it is mounted on a steel I-beam structure. The objective protrudes slightly over the north edge of the drum and is at an elevation of approximately 30 feet above the ground level. There are no wind breaks about the telescope or mounting.

During the period March 3 to March 16, six exposures of 15 minutes each were made per night, two each at 21^h, 24^h and 3^h (MST); after March 16 three 15-minute exposures were made, one at each of the stated times.

TABLE I

Journal of Observations

Date 1971	Time (Start) MST	Film Roll	Film Exp.	Temp. °F	Rel. Hum. %	Wind Vel.	Wind Dir.	Seeing (Sec. of Arc)	Obs.
March 3/4	21:05	1	1	34	40	0	-	<0.7	TK
	21:20	1	2	34	40	0-5	SSW	0.7	JG
	00:20	1	3	33	45	5-7	SSW	0.8	TK
	00:35	1	4	22	45	5-7	SSW	1.2	TK
	03:05	1	5	32	45	5-7	SW	1.2	TK
	03:20	1	6	32	45	5-7	SW	1.8	JG
4/5	21:26	1	7	31	53	15	SW	2.0	MH
	21:43	1	8	31	53	15	SW	2.0	MH
	00:05	1	9	30	62	20	SW	2.5	MH
	00:20	1	10	30	62	20	SW	3.0	MH
5/6	21:00	1	11	20	55	5	NW	6.0	JF
	21:05	1	12	20	55	5	NW	6.0	JF
	21:15	1	13	20	55	5	NW	6.0	JF
	23:50	1	14	25	25	10-20	NNW	5.0	JF
	00:15	1	16	25	25	10-20	NNW	5.0	JF
	02:55	1	17	25	18	2-9	NNW	1.8	JF
	03:10	1	18	25	18	2-9	NNW	2.0	JF
9/10	21:28	2	2	29	41	0-5	NW	1.3	JG
	00:14	2	3	28	46	0-5	NW	1.5	JG
	00:30	2	4	28	46	0-5	NW	1.6	JG
	03:09	2	6	28	45	0-5	NW	2.0	JG
	03:21	2	7	28	45	0-5	NW	2.0	JG
11/12	21:08	2	8	32	44	0-5	SSW	1.5	TK
12/13	21:00	2	9	35	56	8-10	S	2.0	MH
	21:16	2	10	35	56	8-10	S	2.0	MH
	00:00	2	11	34	74	10-15	S	1.9	MH
	00:30	2	13	34	74	10-15	S	1.6	MH
	03:00	2	14	34	82	10-15	S	4.0	MH
	03:15	2	15	34	82	10-15	S	41.0-5.0 var	MH
16/17	20:50	3	1	40	23	8	S	1.0	JF
	21:10	3	2	40	23	8	S	0.8	JF
	21:15	3	3	40	23	8	S	1.0	JF
	23:50	3	4	38	24	8	S	1.9	JF
	00:00	3	5	38	24	8	S	1.2	JF
	02:46	3	6	38	24	8	S	1.2	JF
	03:00	3	7	38	24	8	S	1.7	JF
17/18	21:04	3	8	34	29	15,gusts to 20	SW	5.0	MH
	00:00	3	9	32	34	20,gusts to 30	W	5.0	MH
	03:04	3	10	32	38	15,gusts to 20	W	5.0	MH

TABLE I

Continued

Date 1971	Time (Start) MST	Film		Temp. °F	Rel. Hum. %	Wind		Seeing (Sec. of Arc)	Obs.
		Roll	Exp.			Vel.	Dir.		
March 20/21	21:35	3	111	32	25	0-5	W	1.5	JF
	01:05	3	12	31	25	5	SW	1.3	JF
	03:05	3	13	29	25	0-5	SW	1.6	JF
27/28	20:50	3	14	42	56	8	W	1.3	JF
	23:45	3	15	39	90	8	W	1.5	JF
	02:50	3	16	36	72	6	W	1.5	JF
April 3/4	21:00	4	2	38	28	20	N	4.0	JF
	00:00	4	3	37	27	5	N	4.0	JF
	03:00	4	4	37	30	6	N	4.0	JF
5/6	20:55	4	5	42	32	0	-	0.9	TK
	23:56	4	6	36	30	0	-	0.8	TK
	03:05	4	7	39	32	3	W	1.0	TK
	03:20	4	8	39	32	3-6	W	1.0	TK
6/7	21:10	4	9	43	38	7	SE	1.5	JF
	23:45	4	10	42	43	10	SE	1.7	JF
	02:45	4	11	39	38	4	SSW	1.2	JF
7/8	23:50	4	13	37	27	5-25	SW	6.0	JG
	02:55	4	14	36	38	10-30	SW	4.0	JG
8/9	21:25	4	15	48	26	10-15	SW	1.5	GC
	23:58	4	16	45	28	10-15	S	1.6	GC
	02:45	4	16	42	34	10-15	S	1.5	TK
May 19/20	21:02	5	1	47	14	4	S	1.0	MH
	00:00	5	2	-	-	5-10	S	1.0	MH
	03:00	5	3	-	-	7-10	S	1.7	MH
June 3/4	21:00	5	5	36	58	8-10	W	5.0	MH
	00:00	5	6	34	76	10-12	S	1.8	MH
	03:00	5	7	36	58	10-12	S	1.5	MH
9/10	21:00	5	8	46	52	8-10	S	2.5	MH
	00:00	5	9	42	79	15-20	SE	1.7	MH
	02:50	5	10	40	70	15-20	SE	3.0	MH
29/30	21:06	5	11	55	30	0	-	1.5	MH
	00:00	5	13	54	32	4-6	S	1.0	MH
	03:00	5	14	54	30	7-10	S	1.0	MH

The following observers (identified by initials in Table I) have participated in this program: George Coyne, Jack Frecker, John Gradie, Morris Howes and Thomas Kunkle. The exposed film rolls were sent to Dr. Walker who developed the film, compared the star trails to his standard calibrated trails, and sent to me the results listed in column 9 of Table I. Temperature and relative humidity were read by each observer from the hygrothermographs, which are monitored weekly by Ewen Whitaker. Wind velocity and direction were measured from a hand-held meter or read from a wind vane mounted at the west edge of the drum. The 25 percentile of the relative humidity by Table I is 27% (instrument reading); however, checks made with a psychrometer show that the instrument gave readings averaging about 4% too high.

Observations were made during a total of 19 nights during March-June, 1971. A journal of observations is given in Table I and the distribution of the average seeing for each night is given at the bottom of Figure 1. For each night the average seeing over all exposures was determined. However, for the nights of March 5/6, March 12/13 and June 3/4 the seeing changed by a large factor in the course of the night so that the last two exposures are treated as a separate night for each of these three nights. A total of 22 nights are, therefore, plotted in Figure 1. The average seeing over all nights is 2".1.

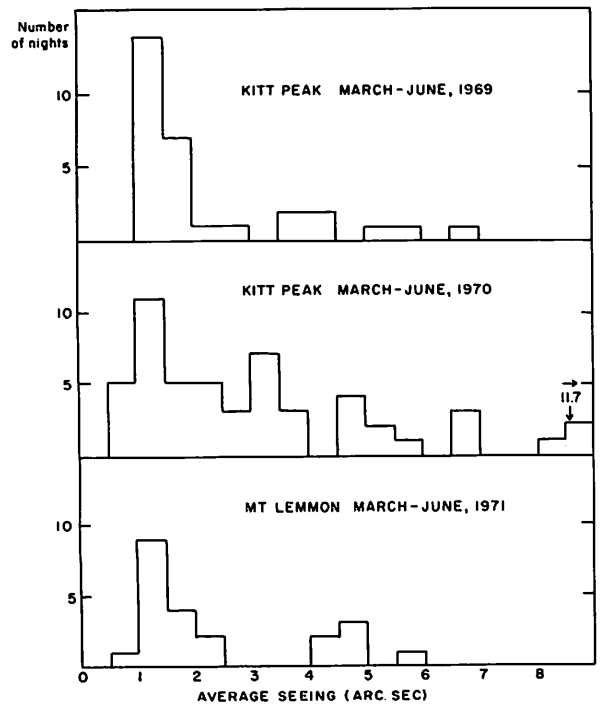

Fig. 1 Distribution of the average seeing (in seconds of arc) per night at Mt. Lemmon and at Kitt Peak during the same season but for different years.

There are obviously too few observations from which to make any conclusive statements on the seeing at Mt. Lemmon. As a preliminary step, we make a comparison in Figure 1 between our Mt. Lemmon observations and those made at Kitt Peak with the same instrument for the same months, but for the two previous years. The information for Kitt Peak is from Walker (1971). At Kitt Peak the Polaris telescope was mounted on a concrete pier just west (up-wind) of the 36-inch No. 1 telescope, with its objective about 9 feet above ground level. The two years on Kitt Peak are sufficiently different to caution against general conclusions. All one can say is that the 1971 Mt. Lemmon run is not unlike the Kitt Peak runs made in 1969 and 1970.

It was feared that vibrations of the telescope by the wind might be introducing false seeing effects into the star trails, although there was no direct evidence for this, visually or photographically. In Figure 2 we have plotted the seeing for each individual exposure against the average wind at the time of that exposure. At wind velocities of 15 mph and less, a wind vibration effect cannot be very large, since both large and small seeing disks are observed. We cannot say what happens at higher velocities. In general, higher wind velocities are a sign of more turbulent conditions and poorer seeing. Therefore, we should expect some correlation between seeing and wind velocity even for a stationary telescope. For the present, the telescope appears to be adequately mounted for the average wind velocities encountered.

In addition to the seeing tests with the Polaris telescope, a sampling was made of air motion across the Mt. Lemmon summit. This was done by flying smoke pots on tethered balloons to elevations of 500 feet and observing the flow pattern of the smoke at various elevations. All flights were made from or near the same radar drum on which the Polaris telescope is mounted. The general results are:

(1) The flow from the eastern quadrants is laminar for wind velocities up to 30 mph.

(2) The air flowing up the steep western slope remains parallel to the ground and does not appear to be turbulent. It passes the drum on the summit, some 30 meters (70 ft.) from the west rim, at the same slope angle as the western slope itself, i.e. it does not curl over the drum.

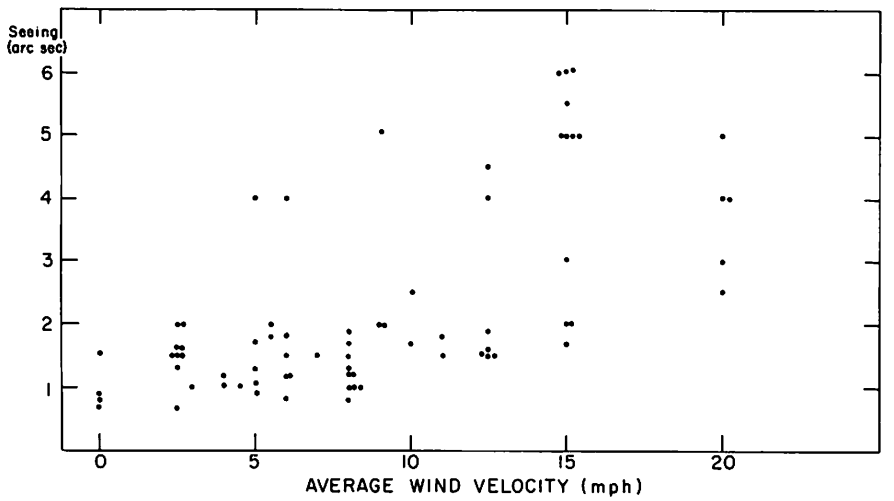

Fig. 2 Estimated seeing (in seconds of arc) plotted versus wind velocity for each individual observation.

(3) The air from the west above this boundary layer flows horizontally at elevations examined up to 500 feet above the drum.

(4) By observing yellow smoke moving upslope at ground level and black smoke moving in from the west horizontally at the level of the drum, we attempted to study what happened at the interface of these two currents. The results are not altogether conclusive but there does not appear to be any serious turbulence. There were certainly no observable eddies and curls where the two currents met at the drum.

(5) All of these tests were made under winter conditions (free air temperatures less than 60°F); warmer air may behave differently.

There is no prominent local air turbulence at the location tested.

Acknowledgment. I would like to thank Dr. Merle Walker for the use of the Polaris telescope, for the development and reduction of the film rolls, and for the use of the seeing data from Kitt Peak antecedent to publication.

REFERENCES

Harlan, E. A. and Walker, M. F. 1965, "A Star-trail Telescope for Astronomical Site-testing," *Pub. A. S. P.*, 77, 246.

Kuiper, G. P. 1970, "High Altitude Sites and IR Astronomy, II," *LPL Comm.* No. 156, 8, 337-383.

Walker, M. F. 1970, "The California Site Survey," *Pub. A. S. P.*, 82, 672.

Walker, M. F. 1971, "Polar Trail Observations of Astronomical Seeing in Arizona, Baja California, Chile and Australia," *Pub. A. S. P.*, 83, 401.