ORGANIZED OBSERVATIONS OF NIGHT-SKY BRIGHTNESS IN JAPAN

HIROKI KOSAI AND SYUZO ISOBE
National Astronomical Observatory
Mitaka, Tokyo 181, Japan

ABSTRACT Observations of the night-sky brightness were organized at 106 places in Japan by a promotion of the Environmental Agency with the help of many local governments. Two kinds of measurements were carried out: 1) Number of stars were counted in a region of triangle formed by Alpha Lyr, Epsilon Lyr, and Zeta Lyr by at least 10 contributors at each point. 2) Photographs of a star field at the zenith at each point were taken with the same type of camera and film. These results gave us a good idea on distribution of night-sky brightness in Japan.

INTRODUCTION

The increase of night-sky brightness is rapid in this decade because of the expansion of city areas. This brings, as a result, the loss of a large number of good sites for astronomical observations in the world. In Japan also, we have only limited areas with very dark night-sky. There have been a series of big discussions in Japan on air pollution, since over 100 million inhabitants live in only 378 thousands km^2. The Environmental Agency in Japan is in charge of this problem and organized a campaign to realize the presently considered question as one of their efforts. With much support from local governments, in 1986 they chose 267 cities attending to the campaign, out of about 3000. After one year's preparation, two periods of organized observations of night-sky brightness were carried out. As a preliminary one in February 1987, and as a real one in August 1987. We used all the data obtained during the campaign with the permission of the Environmental Agency and will show some results after reduction of the data.

OBSERVATIONS

Two kinds of observations were carried out. One is to find the faintest star in a selected area by eye, using a binocular telescope with a diameter of 50mm and 7 times magnification or equivalent, and the other is to measure the background darkness on photographs of color slide film with ISO 400 taken at the zenith by a camera with a focal length of 50mm, F/3.5, and exposure times of 80 sec, 150 sec, and 300 sec.

To make the observations effective, preliminary observations of the first

https://doi.org/10.1017/S0252921100003651 Published online by Cambridge University Press

type were organized at 15 public planetariums in February and March 1987. At each place, about 10 people, some of who have much experience to look at night-sky and the other of which have less, counted the number of stars in the Pleiades area. It is clear that the counted number of stars in the area depends on the observers' ability and weather conditions, but we could conclude that the results reflect somewhat actual sky conditions.

Following this success, observations of night-sky were proceeded in August 1987. At these summer time observations, at least 10 contributors at each point tried to find the faintest stars in a triangle area enclosed by Alpha Lyr, Epsilon Lyr, and Zeta Lyr. The mean magnitude of the faintest stars obtained by contributors at each place is given in Table 1. The percentages of about 3000 contributors in different age groups are as follows: 43% for persons with an age of 10 - 19, 15% with 20 - 29, 28% with 30 - 49, and 5% with older than 50. 25% of contributors were people who observed frequently.

Photographs of the zenith were simultaneously taken at each observing place as written in a previous paragraph. To have a well calibrated data a density wedge should be exposed on a black and white film. However, it is rather difficult for many local governments to prepare such an elaborate system. Therefore, we introduced a color slide film for this campaign assuming all the exposed films would be developed by a standard method by that film maker who promised us only several percent of variation on the background darkness of developed films. All of the developed films were collected and measured by a Sakura densitometer PDA 15 with an aperture of 0.5mm. The background density on each photograph given in Table 1 is a mean value of several measurements.

RESULTS

All the reduced data are shown in Table 1 and Figure 1. Sequential number is given for all the attending cities in an order from north to south with a grouping by prefecture, and these distributions in Japan are shown in Figure 2. The third column shows weather conditions at the observing locations; 1) very fine, and 2) fine. A mean value for the limiting magnitude obtained by all the contributors at each place is in column 4. The mean background density of three photographs with exposure times of 80s, 150s, and 300s at each place, and the density range of three photographs, are in columns 5 and 6, respectively. The last two columns show the mean density value and that of 300s exposure photograph both normalized to those for Nishitosa village in Kochi prefecture as one. Figure 3 shows a relation between background density for a 300s exposure photograph and the density range for photographs with three different exposure times. There is a linear relation, and this suggests that, at a point with a bright sky, the background density of a photograph strongly depends on its exposure time. In other words, one can make the longer exposure at a place with dark sky background, where we obtained the fainter limiting magnitude as shown in Figure 4.

CONCLUSION

From Figures 3 and 4, we can conclude that the observations carried out in our campaign can be a good measure for an estimate of the variation of night-sky brightness, and we can say that we still have some areas with dark night-sky brightness in Japan, but this certainly depends on the expansion of population in those areas.

After the problems of light pollution became realized by our astronomical community, a decade has passed, during which an amateur astronomers' society for protection from light pollution to keep fine night sky was organized at the time of appearance of meteorite shower of Giacobini on October 1972. Their efforts have continued and they helped a lot in this campaign organized by the Environmental Agency. We hope this type of campaign by the Agency will be continued to keep good night sky conditions.

TABLE I LIMITING MAGNITUDE AND MEAN BACKGROUND DENSITY AT 106 OBSERVING SITES

	Place	Weather	Mag	logD(m)	logD(R)	Factor	
Hokkaido							
1	Sapporo	1	9.3	3.04	0.14	1.7	1.7
2	Hakodate	2	8.4	1.57	0.89	51.3	123.0
3	Muroran	2	8.1	2.75	0.34	3.4	4.3
4	Rumoi	2	9.4	2.83	0.08	2.8	2.6
5	Nakashibetsu	1	8.7	1.66	0.72	41.7	104.7
Aomori							
6	Hirosaki	1	8.3	2.92	0.41	2.3	3.2
7	Kuroishi	1	6.8	2.93	0.40	2.2	3.2
8	Shingo	2	9.2	2.97	0.28	2.0	2.5
Iwate							
9	Kamaishi	1	9.5	2.85	0.57	2.7	4.2
10	Maezawa	2	9.3	2.69	0.85	3.9	11.2
Miyagi							
11	Sendal	2	8.4	1.61	0.99	46.8	123.0
12	Tagajo	2	9.9				
Fukushima							
13	Iwaki	1	9.0	3.12	0.07	1.4	1.3
14	Fukushima	1	10.3	3.15	0.02	1.3	1.3
15	Aizuwakamatsu	2	8.9	2.36	0.70	8.3	16.6
16	Koriyama	1	8.8	2.66	0.23	4.2	4.2
Ibaraki							
17	Mimaminasu	2	9.5	3.02	0.09	1.8	1.7
Saitama							
18	Urawa	2	8.8	1.43	0.87	70.8	170
19	Kawagoe	1	5.1	1.90	0.89	24.0	57.5
20	Kumagaya	1	8.3	2.32	0.71	9.1	18.6
21	Iwatsuki	2	6.9	2.07	1.07	16.2	46.8
22	Kitamoto	1	7.6	1.97	0.71	20.4	38.9
23	Toda	2	7.5	0.86	0.61	263	407
24	Moroyama	2	8.3	2.36	0.71	8.3	16.2
25	Kodama	1	5.7	1.17	0.44	129	200
26	Higashichichibu	2	9.4	2.76	0.32	3.3	4.4
27	Kamisato	2	8.8	2.68	0.59	4.0	6.8

https://doi.org/10.1017/S0252921100003651 Published online by Cambridge University Press

Chiba							
28	Ichikawa	2	8.0	0.58	0.56	501	741
29	Funabashi	1	8.0	1.79	0.78	30.9	74.1
Tokyo							
30	Oume	2	8.1				
Niigata							
31	Nagaoka	1	6.1				
32	Tookamachi	2	9.2	2.94	0.19	2.2	2.3
Toyama							
33	Takaoka	2	8.0	2.52	0.31	5.8	5.6
34	Fukumitsu	1	9.1	3.07	0.05	1.6	1.4
Ishikawa							
35	Anamizu	2	9.0	3.02	0.00	1.8	1.5
36	Yanagita	2	9.5	2.98	0.06	2.0	1.8
Fukui							
37	Fukui	1	9.1	1.83	1.00	28.2	74.1
38	Tsuruga	1	8.1	2.79	0.46	3.1	4.6
39	Obama	2	8.8	3.04	0.10	1.7	1.7
40	Oono	1	9.8				
Yamanashi							
41	Kofu	2	10.9	3.15	0.03	1.3	1.1
42	Katsumuma	2	8.3	2.85	0.36	2.7	3.5
43	Takane	2	9.2	3.03	0.06	1.8	1.6
Nagano							
44	Matsumoto	1	8.3	2.44	0.64	6.9	12.3
45	Shiojiri	2	9.0	2.81	0.29	3.0	3.5
46	Usuda	2	9.1	2.90	0.03	2.4	2.1
47	Maruko	1	9.5	2.90	0.13	2.4	2.4
48	Shimosuwa	2	9.4	3.08	0.13	1.6	1.5
49	Toyoshina	2	9.1	2.67	0.48	4.1	6.3
50	Hodaka	2	9.3	2.83	0.40	2.8	3.9
51	Gifu	1	8.1	1.93	0.54	22.4	34.7
Shizuoka							
52	Hamamatsu	2	9.2	2.53	0.74	5.6	11.5
53	Gotenba	2	8.9	3.04	0.03	1.7	1.5
Aichi							
54	Handa	1	8.5	2.10	0.43	15.1	22.9
55	Toyoda	2	9.0	2.88	0.04	2.5	2.2
56	Anjo	2	8.0	1.31	0.94	93.3	229
57	Mimamichita	2	8.6	2.90	0.12	2.4	2.3
58	Taketoyo	1	8.4	1.55	1.81	53.7	257

https://doi.org/10.1017/S0252921100003651 Published online by Cambridge University Press

59	Hachikai	1	8.3	2.67	0.65	4.1	7.9
Mie							
60	Suzuka	1	9.3	2.71	0.41	3.7	5.2
61	Nabari		8.8	2.92	0.23	2.3	2.5
Siga							
62	Nagahama	1	8.6	3.01	0.29	1.9	2.2
63	Hikone	1	8.9	2.53	0.58	5.6	9.8
64	Omihachiman	2	9.0	2.75	0.42	3.4	5.0
65	Kusatsu	2	7.0	2.06	0.81	16.6	34.7
66	Hino	1	8.5	3.23	0.09	1.1	1.1
Osaka							
67	Izumi	1	9.1	2.50	0.91	6.0	15.8
Hyogo							
68	Amagasaki	2	7.6	2.40	0.90	7.6	19.1
69	Akashi	2	8.1	2.40	0.75	7.6	15.8
70	Takasago	1	7.9	1.92	1.02	22.9	64.6
71	Mikata	2	8.5	2.03	1.04	17.8	43.7
Ayama							
74	Kasaoka	2	8.7	2.94	0.16	2.2	2.2
75	Bisel	2	9.3	3.02	0.13	1.8	1.8
76	Oosa	2	9.2	3.05	0.01	1.7	1.4
77	Mariwa	2	9.3	2.97	0.07	2.0	1.7
78	Yubara	2	8.9	3.10	0.00	1.5	1.3
Hiroshima							
79	Fukuyama	2	7.1	2.37	1.01	8.1	25.1
80	Mihara	2	8.4	2.59	0.65	4.9	8.9
81	Ootake	1	8.9	3.16	0.00	1.3	1.1
82	Yuki	2	9.3	3.13	0.06	1.4	1.3
83	Osaki	2	9.4	3.18	0.03	1.3	1.1
Yamaguchi							
84	Hagi	1	8.4	2.70	0.47	3.8	5.5
Ehime							
85	Iyo	2	8.7	1.55	0.88	53.7	135
86	Niihama	2	8.6				
Kochi							
87	Kahoku	2	8.5	3.20	0.13	1.2	1.2
88	Nishitosa	2	9.3	3.28	0.12	1.0	1.0
89	Yusuhara	1	8.8	3.24	0.01	1.1	0.9

Fukuoka							
90	Kitakyusyu	2	8.2	1.92	0.48	22.9	39.8
91	Omuda	2	9.1	3.06	0.13	1.7	1.7
Saga							
92	Imari	2	8.9	2.68	0.05	4.0	3.5
Nagasaki							
93	Nagasaki	2	8.2	2.73	0.38	3.5	4.5
94	Saseho	2	9.1	3.06	0.04	1.7	1.4
95	Nishiarie	2	8.3	3.17	0.04	1.3	1.1
Ooita							
96	Kusu	1	9.8	2.90	0.13	2.4	2.4
97	Maetsue	2	9.5	3.04	0.03	1.7	1.5
Miyazaki							
98	Nobeoka	1	8.8	2.93	0.08	2.2	2.0
99	Aya	2	9.1	2.28	0.00		
100	Takasaki	2	11.1				
101	Takachiho	2	9.7	3.00	0.01	1.9	1.6
102	Nango	2	8.9	3.00	0.11	1.9	1.8
103	Kitago	1	8.9	2.91	0.08	2.3	2.1
Kagoshima							
104	Kagoshima	2	9.0	2.86	0.19	2.6	3.0
105	Kaseda	2	9.4	2.85	0.02	2.7	2.2
106	Kajiki	2	9.0	2.93	0.41	2.2	3.2

ACKNOWLEDGEMENTS

Authors would like to express their sincere thanks to the Environmental Agency.

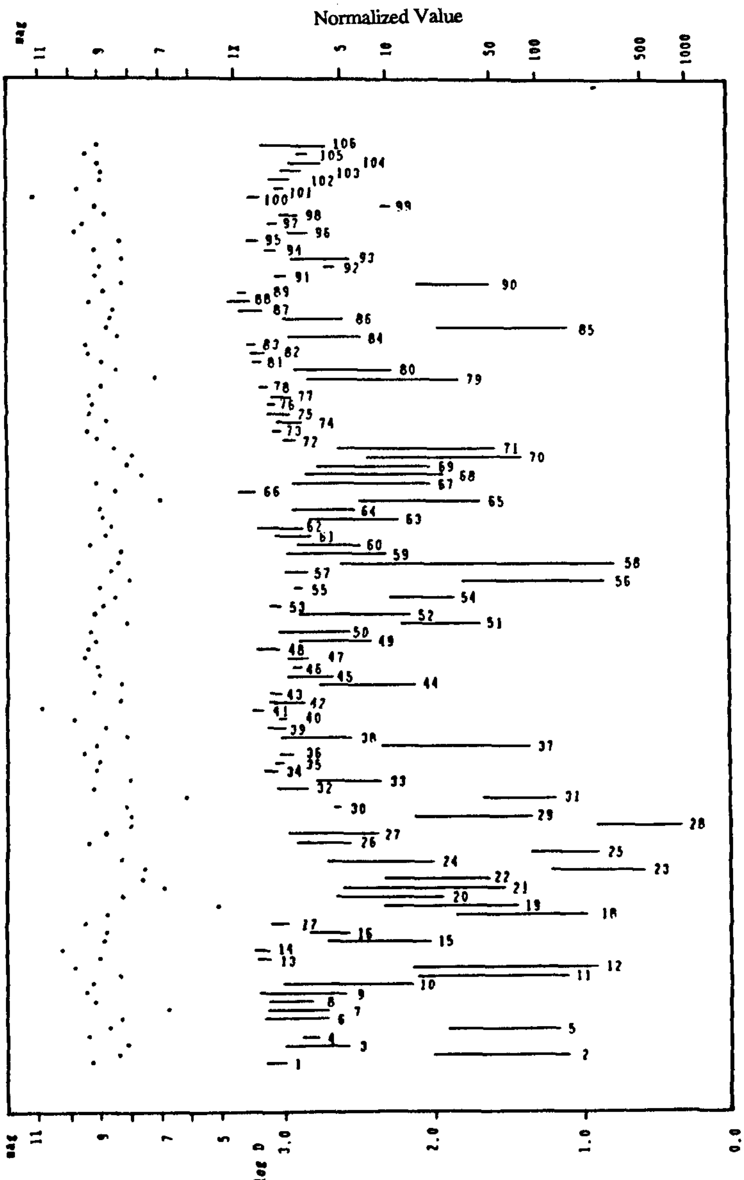

Figure 1. Limiting magnitude and mean background density at 106 observing sites. Each vertical bar shows the density range for photographs with three exposures of 80s, 150s, and 300s.

https://doi.org/10.1017/S0252921100003651 Published online by Cambridge University Press

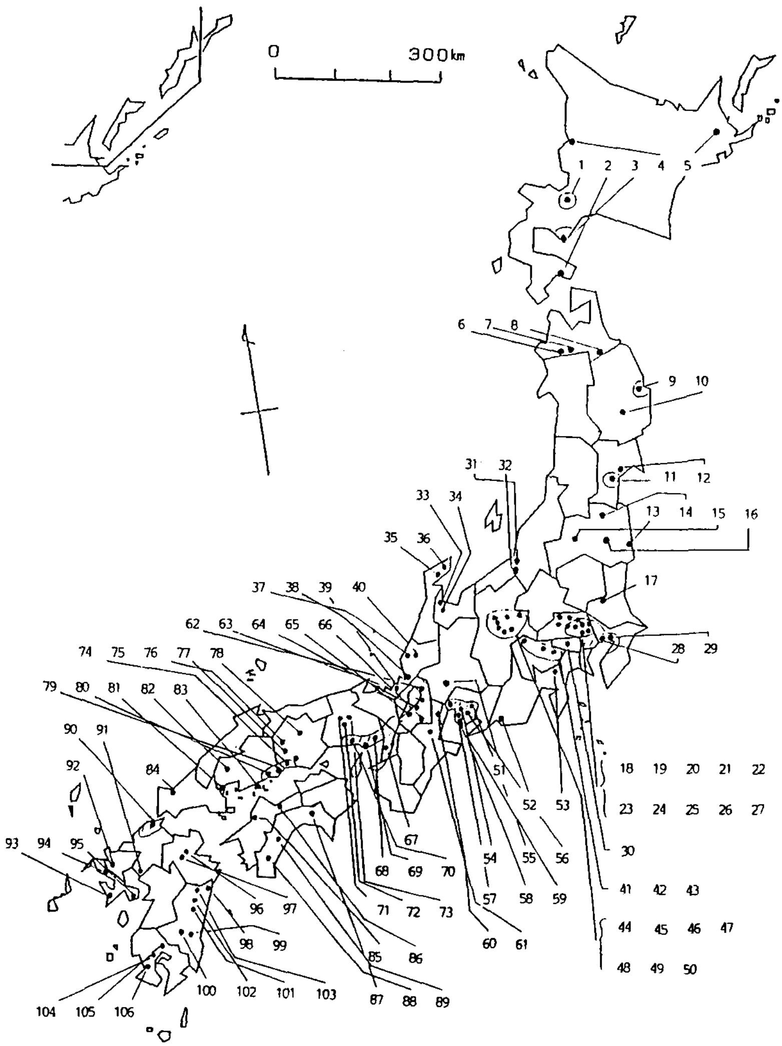

Figure 2. Distribution of 106 observing sites in Japan.

https://doi.org/10.1017/S0252921100003651 Published online by Cambridge University Press

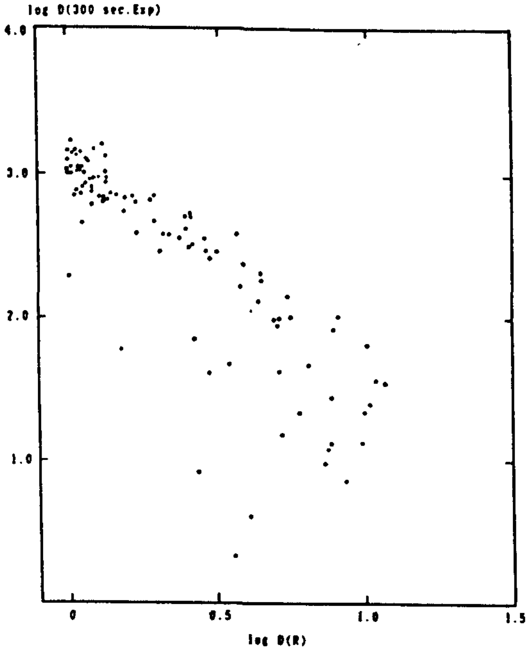

Figure 3. Relation between background density for a 300s exposure photograph and the density range for photographs with three exposure times.

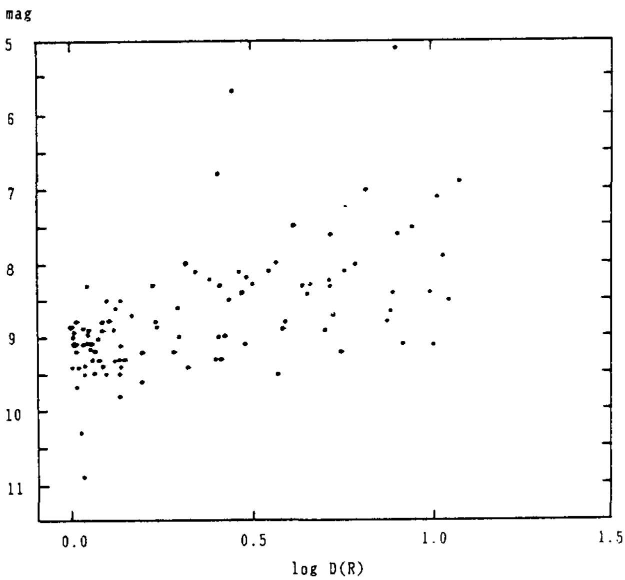

Figure 4. Relation between limiting magnitude and the density range for photographs with three exposure times.

https://doi.org/10.1017/S0252921100003651 Published online by Cambridge University Press