Bull. Astr. Soc. India (1990) **18**, 1-6

Atmospheric extinction measurements at Leh in near infrared bands

J. C. Bhattacharyya, K. K. Scaria, Jagdev Singh, G. S. D. Babu, R. Muraleedharan Nair and K. R. Sivaraman
Indian Institute of Astrophysics, Sarjapur Road, Koramangala, Bangalore 560 034

Received 1989 February 8; accepted 1990 January 10

Abstract. Site survey observations to determine the extinction in the IR bands were carried out at Leh. Mean extinction coefficients obtained from two nights' observations in J, H and K bands are $k_J = 0.05 \pm 0.01$; $k_H = 0.04 \pm 0.01$; and $k_K = 0.04 \pm 0.01$.

Key words : photoelectric photometry—extinction coefficients in IR—site survey

1. Introduction

From spectroscopic studies it has been shown that attenuation in infrared bands is due to absorption by CO_2, H_2O and O_3 molecules, although they form the minor constituents of the atmosphere. In addition, there is the attenuation due to scattering by gaseous molecules, solid particles and liquid droplets present in the atmosphere. Detailed studies have shown that the above absorbing constituents exhibit considerable variation in their distribution from place to place. Also their distribution has a steep vertical gradient so that for measurements in IR bands, location of the observations at high altitude is definitely advantageous.

The high plateau of Ladhak in Himalayas is a semiarid region with an annual water precipitation of 12 to 25 cm distributed more or less uniformly over the year. Average altitude of the place is about 3300 m above mean sea level. There are many intervening ridges which reach altitudes of 4800-5400 m. Atmospheric scattering of light at such high altitudes is generally small and the sky is coronographic. This region is situated far from sources of atmospheric pollution by CO_2, one of the main IR radiation absorbing constituents of the atmosphere. At the existing telescope sites in India, at Kavalur and Nainital, the minimum moisture hardly comes down below 5 to 7.5 cm of precipitable water. But spot measurements of water vapour at Leh the capital city of Ladhak, during the observing season, give values lower than 2 to 3 mm (Bhatnagar 1974). This makes Ladhak region dry enough for IR measurements. But the actual IR transparency at the site could be judged only after direct IR extinction measurements.

Extinction measurements in standard visual bands have been conducted at Leh since 1986 (Singh *et al.* 1990). Such measurements in IR bands were carried out in August 1988 and in this paper we describe the results from these measurements.

2. Instrumentation and observations

Extinction measurements were made using the 50 cm reflector already in operation at Leh. The same IR photometer designed for the 100 cm reflector of the Vainu Bappu Observatory, Kavalur (Shivanandan *et al.* 1987) was used at the f/13 cassegrain focus of the 50 cm reflector. This photometer with its liquid nitrogen cooled InSb detector, has five filters to isolate the J (1.2μ), H (1.63μ), K (2.25μ), L (3.75μ) and M (4.7μ) bands of the Johnson system. The photometer-amplifier combination was operated in the DC mode and the signals were recorded on a strip chart recorder.

During 1988 August 2-13 the Leh skies were clear and photometric for only two nights, on 4th and 6th. α Boo ($m_v = 0.24$, Sp. class = KO) and α Aql ($m_v = 0.89$, Sp. class = A5) chosen as standards were observed from small to large values of hour angles, observations covering a wide range of air mass. Deflections were obtained in J, H, K, L, and M band filters.

3. Results

In figure 1, the observed apparent magnitudes of star α Boo are plotted against the air mass. Though the observed stars were bright, no signals to the level of recognition were

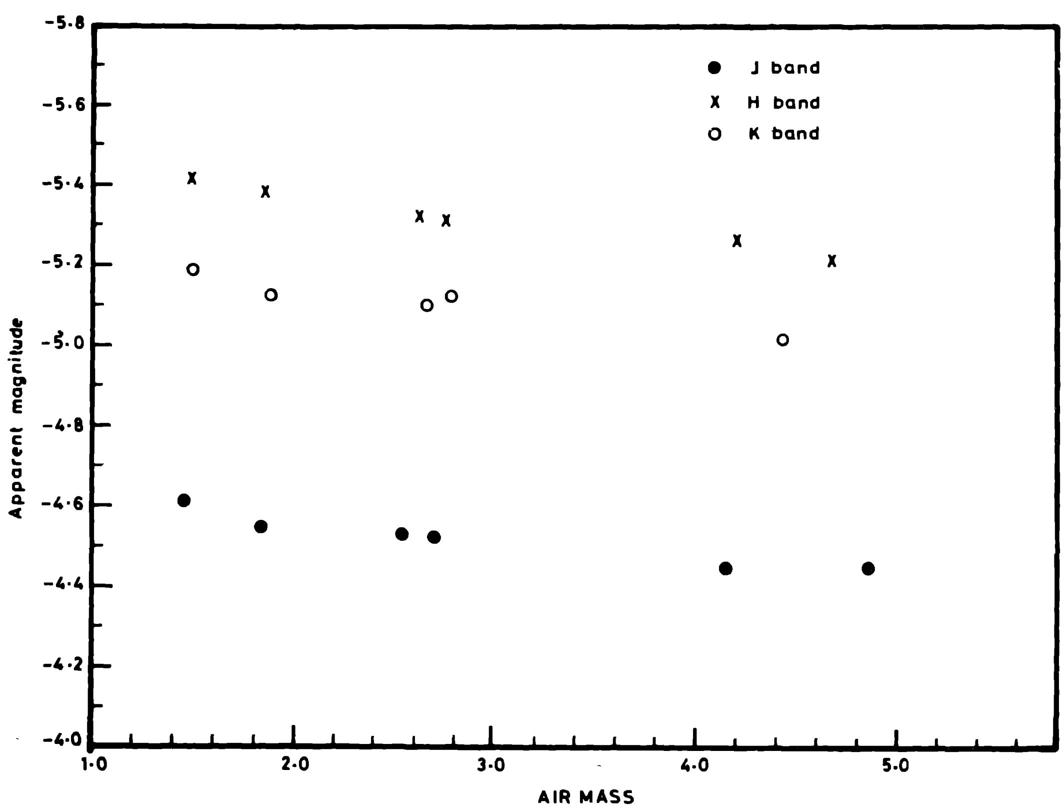

Figure 1. A plot of observed magnitude against air mass in J, H, and K bands.

detected through the L and M filters. We made least square fit to the observations in the J, H and K bands and the following are the mean values of extinction coefficients derived from the two days' observations:

$$k_J = 0.05 \pm 0.01$$
$$k_H = 0.04 \pm 0.01$$
$$k_K = 0.04 \pm 0.01$$

Singh *et al.* (1989) have derived the extinction coefficients in the U, B, and V bands for Leh. In figure 2 the extinction coefficients obtained at Leh in *UBV* and *JHK* bands are plotted against their effective wavelengths. The extinction coefficients in *UBV* bands obtained at the McDonald Observatory (altitude = 2070 m) by Hiltner (1956) and at the Mount Wilson Observatory (altitude = 1740 m) by Abbott (1929) are also plotted in the same figure for comparison. It is clear, that the sky transparency at Leh is poorer than the skies that prevailed at McDonald and Mt. Wilson observatories at the time of the observations used here for comparison, even though the altitude of Leh is much higher than that of the other two sites.

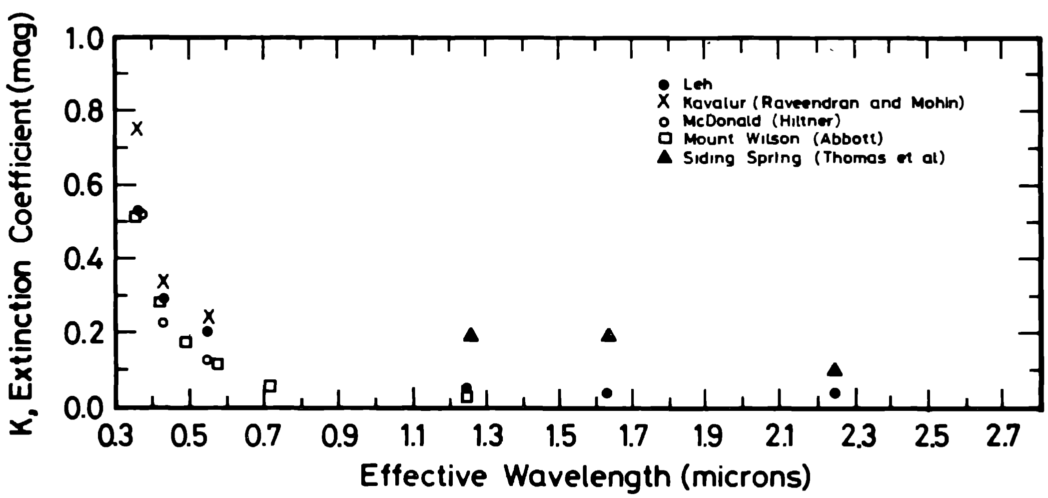

Figure 2. Variation of extinction coefficient, k, with wavelength. Open circles represent McDonald Observatory; filled circles Leh; crosses Vainu Bappu Observatory, and triangles Siding Spring Observatory. [Kavalur data are from A. V. Réveendran & S. Mohin (1983) personal communication].

The exact reason for the complete absence of signal in the L and M bands could not be judged from the restricted data available from Leh. The performance of an IR detector system is determined by its ability to reject the background noise which comes partly from the inside of the telescope and partly from the atmosphere. This is normally eliminated by modulating the star signal falling on the detector to permit capacitive coupling of the detector to the high gain amplifier. In our instrumental set up, modulation of the signal is done by moving a small mirror near the focal plane to simulate moving the detector back and forth between the two sky positions namely (i) sky and star, and (ii) sky alone. This arrangement produces smallest noise only if the telescope is properly diaphragmed to reduce edge effects. These edge effects are larger in L and M bands. The detector system which was used at Leh was actually designed for the

100 cm reflector at Kavalur and there was not enough time available at Leh to study the proper matching of the detector system with the 50 cm reflector used at Leh for observations.

This could have resulted in larger background noise and a poor signal to noise ratio. Also the month of August is not the ideal time for astronomical observations in the IR bands at Leh. During August, night temperatures at Leh range between 15°C and 25°C (figure 3) and the average humidity ranges from 60% to 80% during night hours (figure 4). These conditions adversely affect the observations in the *L* and *M* bands by enhancing the background noise. But this period was selected for logistical reasons. Liquid nitrogen and some of the heavy equipment used in IR photometry had to be transported from

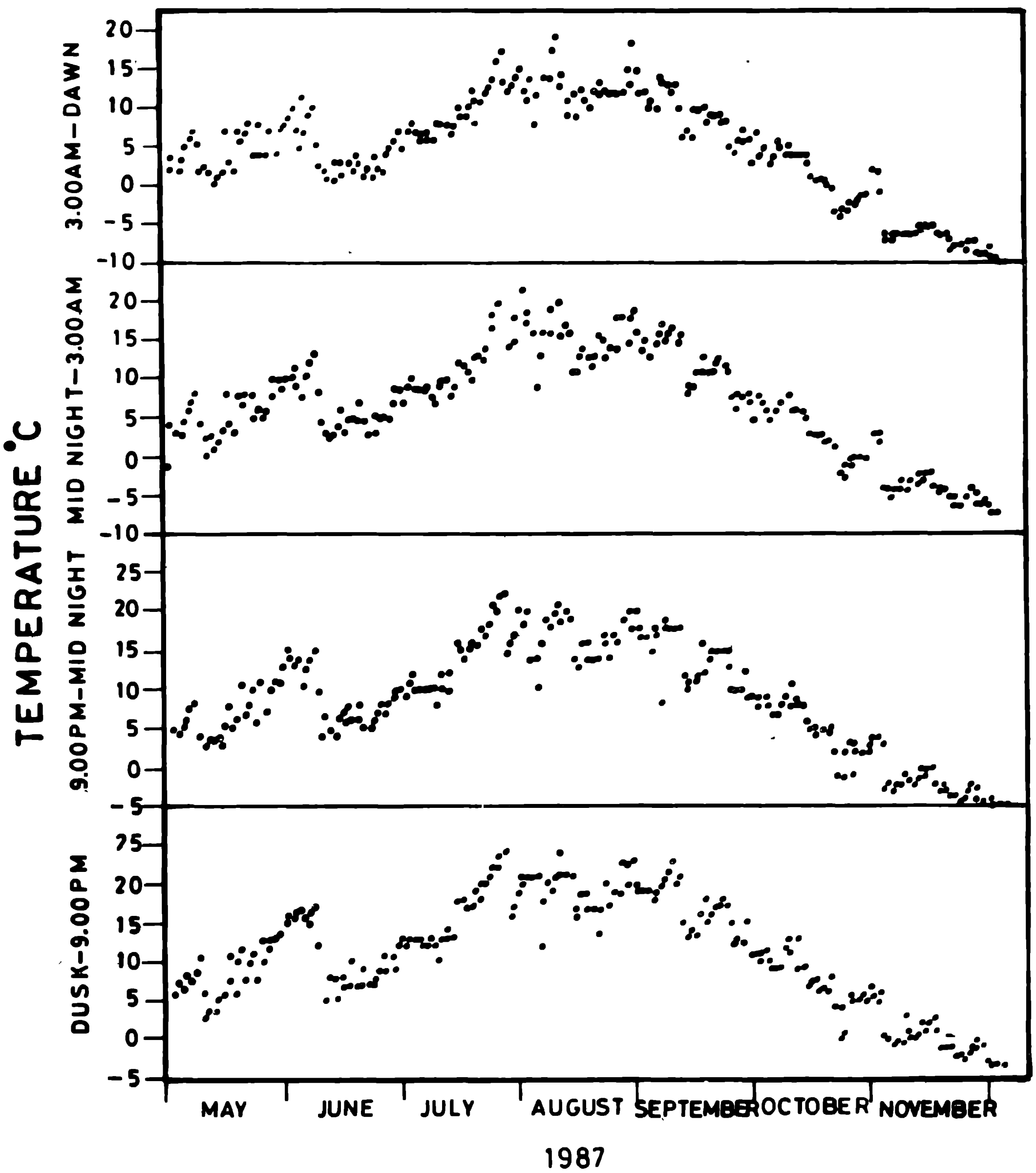

Figure 3. Night time temperature values at Leh taken at an interval of 3 hours during the period 1987 May-November.

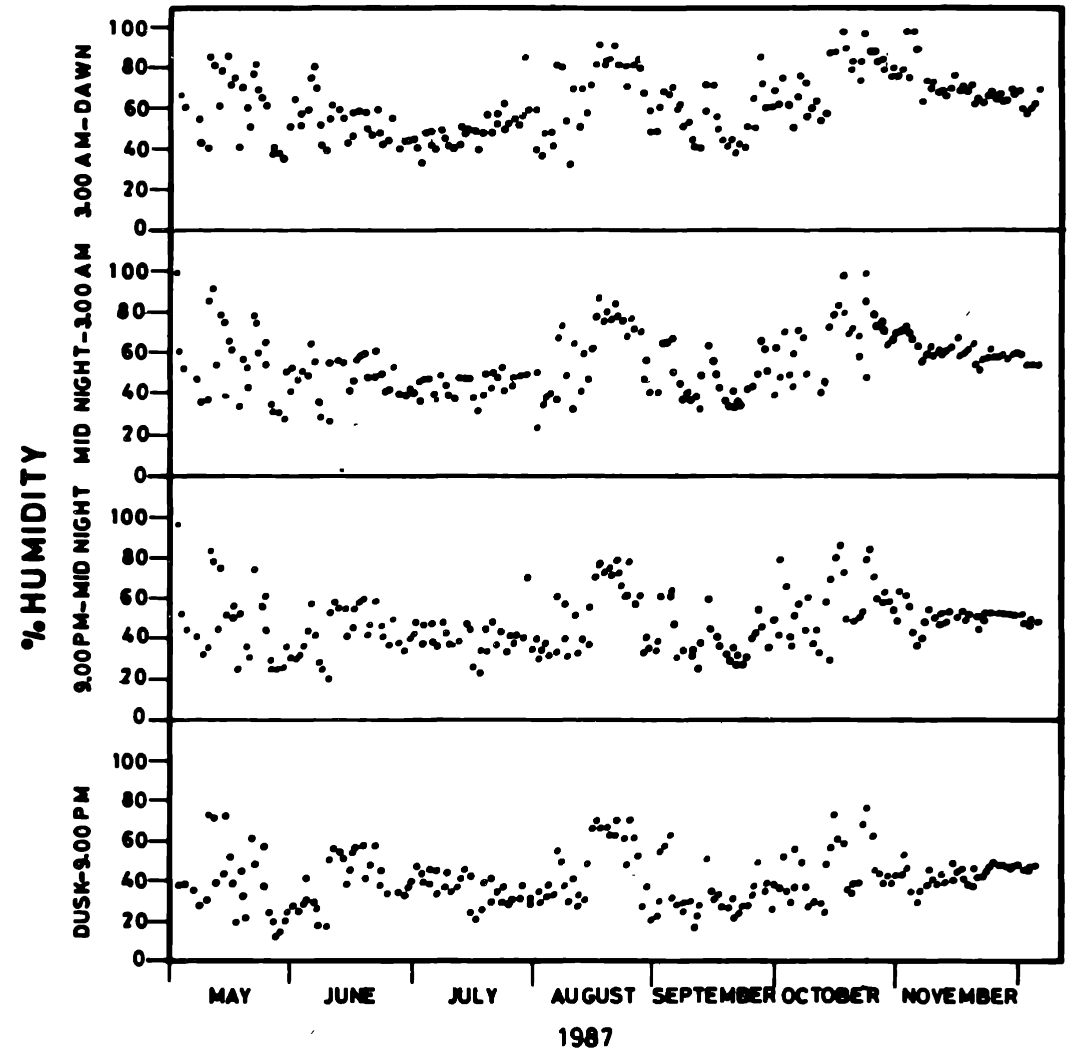

Figure 4. Values of percentage relative humidity at Leh from dusk to dawn taken at an interval of 3 hours during the period of 1987 May-November.

Srinagar to Leh by road which is open for traffic only during the summer months. Our attempts to transport these during the month of May was foiled by nature's vagaries and only by August it could reach Leh. The IR observations were not attempted during autumn months. Extinction coefficients in *J, H*, and *K* bands at Siding Spring Observatory (altitude 1140 m) by Thomas, Hyland & Robinson (1973) are plotted in figure 2. The restricted data available from Leh show that extinction in *J, H*, and *K* bands is small enough for good astronomical observations in IR at Leh.

Acknowledgements

This work was sponsored by the department of science and technology, government of India. We acknowledge the help provided by the persons connected with this department. Local arrangements were looked after by Dr A. Bhatnagar. We thank our colleagues F. Gabriel, J. P. A. Samson, and V. Moorthy for their help at the telescope.

References

Abbott, C. G. (1929) *The sun*, Appleton & Co., New York, p. 297

Bhatnagar, A. (1974) *Proc. of seminar on infrared and millimeter range astronomy* (eds. S M Alladın & K. D. Abhyankar), p. 25.

Hiltner, W. A. (1956) *Ap. J. Suppl.* **2**, 389.

Shıvanandan, K., Scaria, K. K., Naır, R. M., Rajamohan, R. & Sıvaraman, K. R. (1988) *Kodaıkanal Obs. Bull.* **8**, 21.

Singh *et al.* (1989) *Bull. Astr. Soc. Indıa* **17**, 83.

Thomas, J. A., Hyland, A. R. & Robinson, G. (1973). *M.N R.A.S.* **165**, 201.