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Site characterization for the UPSO-TIFR telescope

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Abstract. The Uttar Pradesh State Observatory, Naini Tal and Tata Institute of Fundamental Research, Mumbai plan to install jointly a 3 metre size optical telescope at Devasthal located east of Naini Tal about 50 km by road. The site has been selected after a decade of survey in Kumaon and Garhwal hills. The altitude of the peak is 2450 ± 5 meters, while longitude and latitude are 79° 40′ 57″ E and 29° 22′ 46″ N respectively. The location of the site is such that logistics of access and transportation are not too difficult and at the same time, it is far from urban development, has more than 200 astronomically useful nights, dark sky, low atmospheric extinction and most importantly seeing better than 1 arcsec for about 40% of the time. Extensive efforts are going on to characterize the site more precisely.

Key words : seeing-Atmospheric turbulence-site testing-meteorology

1. Introduction

In 1996, the Uttar Pradesh State Observatory (UPSO), Manora Peak, Naini Tal and Tata Institute of Fundamental Research (TIFR), Mumbai decided to set up jointly a moderate size modern optical telescope in the Central Himalayas. In recent years, it has been realised that putting up such a telescope at a good astronomical site is of paramount importance, as effective utility of the telescope depends on that. For example, for many purposes the power of a telescope is proportional to the primary collecting area divided by the solid angle formed by the image. A 2.5m telescope with 0″.5 seeing is thus equivalent in performance to a 5m telescope with 1″.0 seeing (Wolf, 1982). Hence smaller telescopes located at sites with good seeing can perform better than larger telescopes installed at sites with poor seeing. The site parameters are also required for finalising the design of the telescope and its back end instruments. The characterization of a site before putting up a telescope therefore becomes inevitable. UPSO identified Devasthal as a promising astronomical site by conducting an extensive site survey during 1980 - 1990 in the Shivalik Hills of the Central Himalayan range. Fig. 1 shows a contour map of the Devasthal site. It has been decided to install the UPSO-TIFR telescope at this site. The preliminary results of the site survey carried out so far at Devasthal are presented here. The site survey alongwith the results are described in the following sections. Last section provides the conclusion of the site survey.

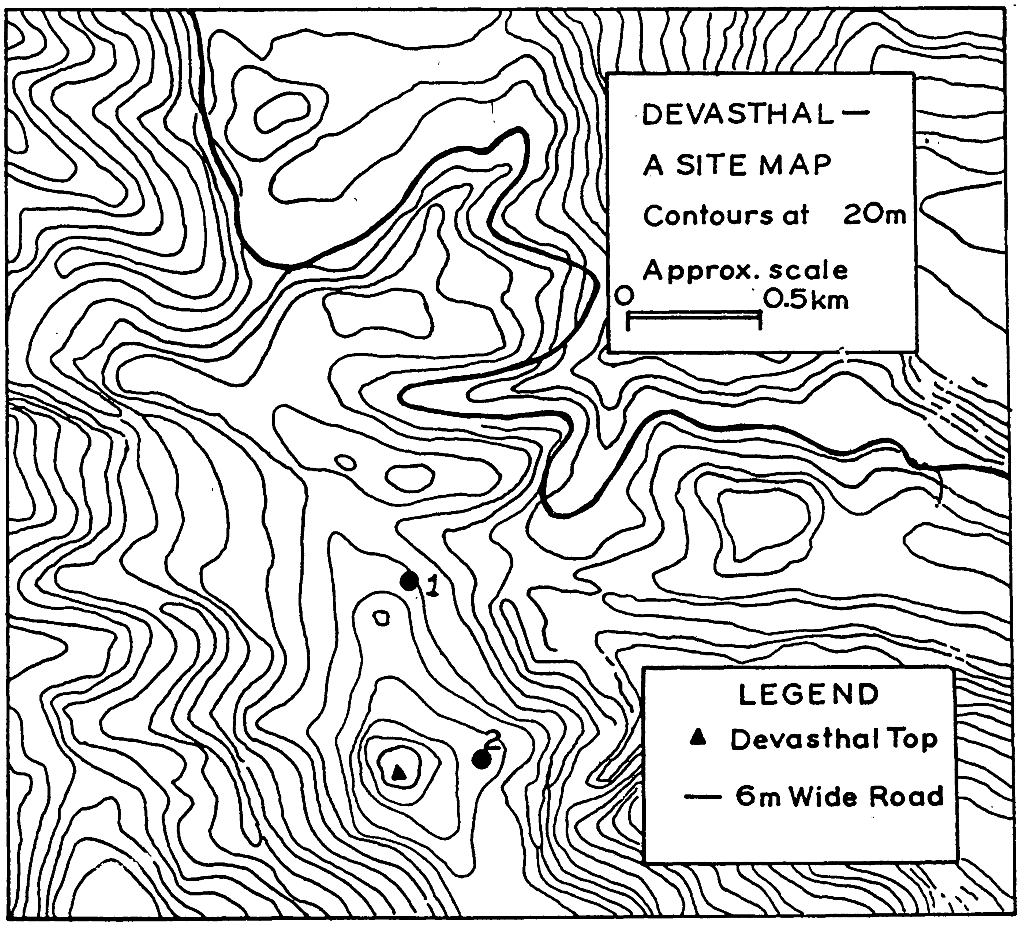

Figure 1. Contour map of Devasthal sites 1 and 2 are marked.

2. The site survey of 1980

As the light pollution has increased considerably and the seeing is also poor ($\geq 1.''5$) at the present site of Manora Peak, UPSO in its urge to install a moderate size optical telescope at an astronomically better site carried out an extensive site survey in the Kumaon and Garwhal regions of Shivalik Himalayas in 1980's. Out of the 36 sites for which informations were initially collected, a total of 5 probable sites (Gananath, Mornaula, Devasthal, Chaukori and Jaurasi) were selected for detailed investigations. Meteorological observations in these sites were carried out during 1982 - 1991. This initial survey finally came up with Devasthal as a potential site for putting up a new optical telescope. Details of the night sky conditions at Devasthal are given in Table 1 where useful (spectroscopic) nights are those when the cloud cover is either zero or < 3 octas at least for 4 consecutive hours.

Table 1. Details of the nights in Devasthal.

Year	Nights Observed	Useful Nights	Cloudy Nights
1987	278	172	106
1988	366	215	151
1989	365	198	167
1990	295	156	139
Total	1304	741	563
Percentage		57%	43%

Table 1 indicates that for about 206 nights in a year optical observations can be carried out at Devasthal. A good fraction of them are of photometric quality. We point out that a recent study based on the INSAT cloud imagery database for the period 1989 to 1994 (Sapru et al., 1998) suggest that the average annual percentage of clear (spectroscopic) nights is about 55% for Devasthal, which is in agreement with the visual observations reported here. A comparison of useful nights at Devasthal vis-a-vis some well known sites around the world can be seen from Table 2. This indicates that the site can be called satisfactory.

Table 2. Number of usable nights at Devasthal and other sites.

Site	Photometric Nights (%)	Spectroscopic Nights (%)
Devasthal (India)	53	57
Hanle (India)	46	61
Leh (India)	42	58
Flagstaff (USA)	40	58
Siding Spring (Australia)	40	65
Mt. Palomor (USA)	--	68
La Palma (Spain)	56	81
Cerro Tololo (Chile)	62	77
La Silla (Chile)	57	82
Mauna Kea (USA)	56	87

3. Recent site survey efforts

As a follow-up on the site survey of 1980s and to characterize Devasthal Site astronomically, a decision was taken in August 1996 to carry out regular meteorological and seeing measurements at Devasthal. Two sites were identified which are separated by 1.5 kms from each other, hereinafter referred to as Site 1 and Site 2 (see Fig. 1). For seeing measurements, a 52 cm telescope is used at Site 1, whereas a 38 cm telescope is used at Site 2. The device used for the seeing measurements is the Differential Image Motion Monitor (DIMM). Its principles of working have been described in detail by Sarazin & Roddier (1990). The front portion of the

52 cm reflector tube is covered by a mask with two 6 cm diameter circular holes separated by 40 cm, whereas in the 38 cm reflector the holes of 5 cm in diameter are separated by 24 cm. These numbers are chosen in such a way that the ratio of separation of the circular holes to the diameter lies between 5 to 7 which provides the best seeing measurements in this type of set up. One of the hole contains a prism which deviates the incoming light by about 30″ so that two separate images of the same star are formed on the CCD chip. One pixel of the CCD chip corresponds to 0.″42 × 0.″49 and 0.″50 × 0.″58 at the focii of 52 cm and 38 cm telescopes respectively. Using DIMM, a series of 10 ms exposures are taken and a hundred such exposures are used to derive one estimate of the seeing. The fluctuations in the relative positions of the two image centroids are used to evaluate the seeing. The measurements were carried out from February 1997 to November 1998 at Site 1 and from October 1998 to December 1998 at Site 2. In Table 3, the statistics of the seeing values obtained at both sites 1 and 2 is given and the histogram of the seeing is given in Figure 2. It is worth pointing out that these numbers have not been corrected for effects due to finite exposure time and CCD noise etc. Such corrections will improve the seeing values.

Table 3. Seeing statistics at Devasthal site.

Items	Site 1	Site 2
Total No. of nights observed (data points)	88(3698)	32(5914)
Minimum seeing (arcsec)	0.5	0.5
Average seeing (arcsec)	1.5	1.1
Median seeing (arcsec)	1.4	1.1
Percentage of data with seeing ≤ 1.″0	7	40
Percentage of data with seeing 1.″0 – 1.″2	16	26
Percentage of data with seeing 1.″2 – 1.″4	22	17
Percentage of data with seeing 1.″4 – 1.″6	21	09
Percentage of data with seeing 1.″6 – 1.″8	12	04
Percentage of data with seeing 1.″8 – 2.″0	10	02
Percentage of data with seeing > 2.″0	12	02

For site survey purpose, an Automatic Weather Station and Microthermal tower described below are also installed close to Site 1.

4. Microthermal Tower

The detection of the local source of seeing degradation which occur in levels of the atmosphere very near the ground within a few tenths of metres of ground is of great importance for deciding the height at which the telescope can be installed practically.

For this we have performed microthermal fluctuations measurements till December 1998 at Site 1 at three different levels, namely 6,12 and 18 meters above the ground. The details of the instrumentation and the analysis can be found in Pant et al. (1999). Briefly, microthermal fluctuations at a level are measured every second using pair of thermal sensors having temperature resolution of 0.01°C. As these fluctuations are related to seeing, the fluctuations averaged over one minute at a level are used to evaluate seeing contribution arising from optical turbulence present between 6 to 12, 6 to 18 and 12 to 18 meter slabs above ground. Microthermal data were successfully recorded on a total of 20 nights during March 1998 to June 1998 and the results of seeing when DIMM and microthermal tower were operated simultaneously are given in Table 4. This shows that microthermal turbulence decreases rapidly from 6 to 18 metre height.

Table 4. Mean and median values of microthermal and DIMM seeing measurements at Devasthal during March to June 1998

Height Range	ε(mean) (arcsec)	ε(median) (arcsec)
6 – 12	1.28	1.17
12 – 18	0.32	0.30
6 – 18	1.36	1.25
DIMM	1.51	1.42

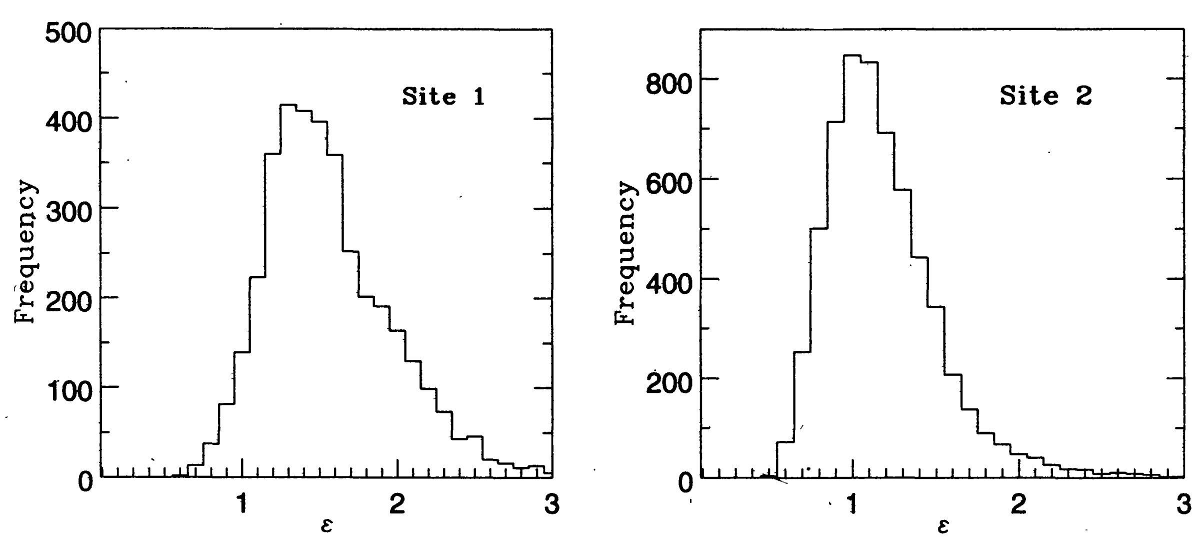

Figure 2. Histogram of seeing at Devasthal Site 1 and Site 2

5. Meteorology

Measurements of meteorological parameters such as air temperature, humidity, wind speed and wind direction are of major importance in understanding the change of optical turbulence near ground level. To accomplish this an all weather station was operational near Site 1 till December 1998. Hourly average of the data recorded every second through appropriate sensors were stored in the data logger. The results of these meteorological observations are

1. Air temperature varies from –4.5° C to 21.5°C. Temperature variation in the night time is generally within 2°C.

2. Relative humidity is mostly below 60% during astronomically useful nights. However humidity during rainy season (end of June to mid of September) goes to much higher values.

3. Hourly average wind speed seldom exceeds 10 m/sec and during 85% of the time it is below 5m/sec. The prevailing wind direction is NW.

4. No correlation of seeing with meteorological parameters is noticed, but for wind speed and air temperature. Seeing seems to deteriorate with increasing wind speed and improve with increasing air temperature.

6. Temporal evolution of seeing

From the point of view of planning observations, a knowledge of the temporal evolution of seeing at Devasthal site is desired. No significant trend is seen when the results of all observing nights are averaged in 30 minute bin and plotted against UT. This is in contrast with the generally prevailing notion among astronomers that the seeing is generally poorer in the beginning of the night and improves later in the night. Our results agree with what have been found for the ORM site at La Palma by Muonz-Tuonn et al.(1997) where no general trend in the seeing evolution is noticed.

7. Extinction measurements

The values of the atmospheric extinction coefficients in Johnson U, B, V and R photometric passbands determined on 20 and 21 January, 1998 using the solid state photometer at the 52 cm telescope is 0.40 ± 0.01, 0.22 ± 0.01, 0.12 ± 0.01 and 0.06 ± 0.01 respectively. Further details of the atmospheric extinction properties of the site are given by Mohan et al. (1999).

8. Conclusions

At Devasthal, the proposed site for the UPSO-TIFR telescope, the hourly average wind speed seldom exceeds 10 m/sec and the prevailing wind direction is NW. Present seeing measurements have proved Site 2 better than Site 1, with mean and median seeing values better than 1.″12 and 1.″07 respectively. Little correlation of seeing is noticed with wind speed and air temperature. Further efforts are going on to characterize the site more precisely.

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