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THE SEEING AT SAN PEDRO MÁRTIR OBSERVATORY AS MEASURED USING THE DIMM METHOD

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RESUMEN

Hemos llevado a cabo un nuevo programa para medir el seeing en el Observatorio Astronómico Nacional en San Pedro Mártir. Los resultados obtenidos durante un período de dos años, esta vez empleando un monitor DIMM, arrojan una calidad de imagen con mediana de 0.59 segundos de arco y un primer cuartil de 0.47 segundos de arco. Mostramos también que el seeing puede ser muy estable durante toda la noche bajo condiciones excelentes. Las mejores medidas arrojan una mediana de 0.37 segundos de arco, obtenidas de observaciones continuas durante casi nueve horas. Nuestros resultados son comparados con un estudio previo del sitio, encontrándose resultados muy similares.

ABSTRACT

We have conducted a new program to monitor the seeing at the site of the Observatorio Astronómico Nacional in San Pedro Mártir. The results obtained during a two year period, this time with a DIMM monitor, yield a median seeing of 0.59 arcsec and a first quartile of 0.47 arcsec. We show that the seeing can be very stable for the whole night under excellent conditions. The best measurements yield a median of 0.37 arcsec during nearly nine hours of continuous observations. Our results, when compared with a previous study of the site, yield very similar results.

Key Words: **ATHMOSPHERIC EFFECTS — TURBULENCE**

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1. INTRODUCTION

A number of studies to evaluate the site of the Observatorio Astronómico Nacional in San Pedro Mártir, Baja California, México, have been made by several authors. Climatological studies since the first years of operation have been published by Mendoza (1973), Alvarez & Maisterrena (1977), Walker (1984), Tapia (1992), Michel et al. (2001), and Hiriart, Ochoa, & García (2001). Water vapor content has been measured by Hiriart et al. (1997) and a thorough study of near–ground atmospheric turbulence and meteorological conditions was conducted by Echevarría et al. (1998). Further studies of the atmospheric turbulence profile above the observatory site were done by Avila, Vernin, & Cuevas (1998) and by Conan et al. (2002).

In this contribution we present the results of a new seeing campaign to evaluate the site of the Observatorio Astronómico Nacional at San Pedro Mártir, this time using a DIMM monitor, see also Michel et al. (2003)) for details. Our previous campaign (Echevarría et al. 1998) was mostly devoted to measuring the seeing by means of the *Carnegie Monitor* and the University of Arizona *Site Testing Telescope*, both systems working with different instrumental techniques. Although this time we have accumulated considerable less data, the results of both campaigns may shed light on the consequences of diverse instrumental characteristics upon seeing evaluation.

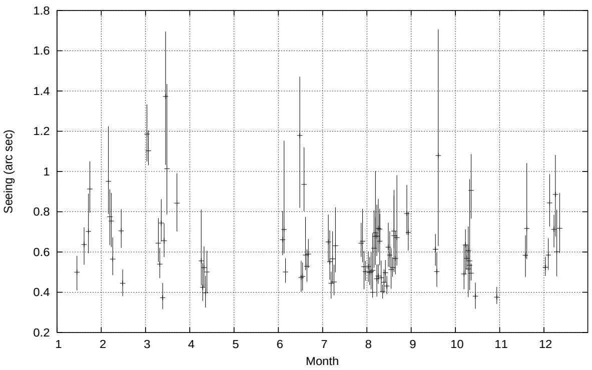

Fig. 1. Nightly seeing measurements. The bars represent the first and third quartiles.

2. INSTRUMENTATION AND OBSERVATIONS

We used a two-aperture Differential Image Motion Monitor (DIMM) from LHESA Electronique, very similar to the one described by Vernin &

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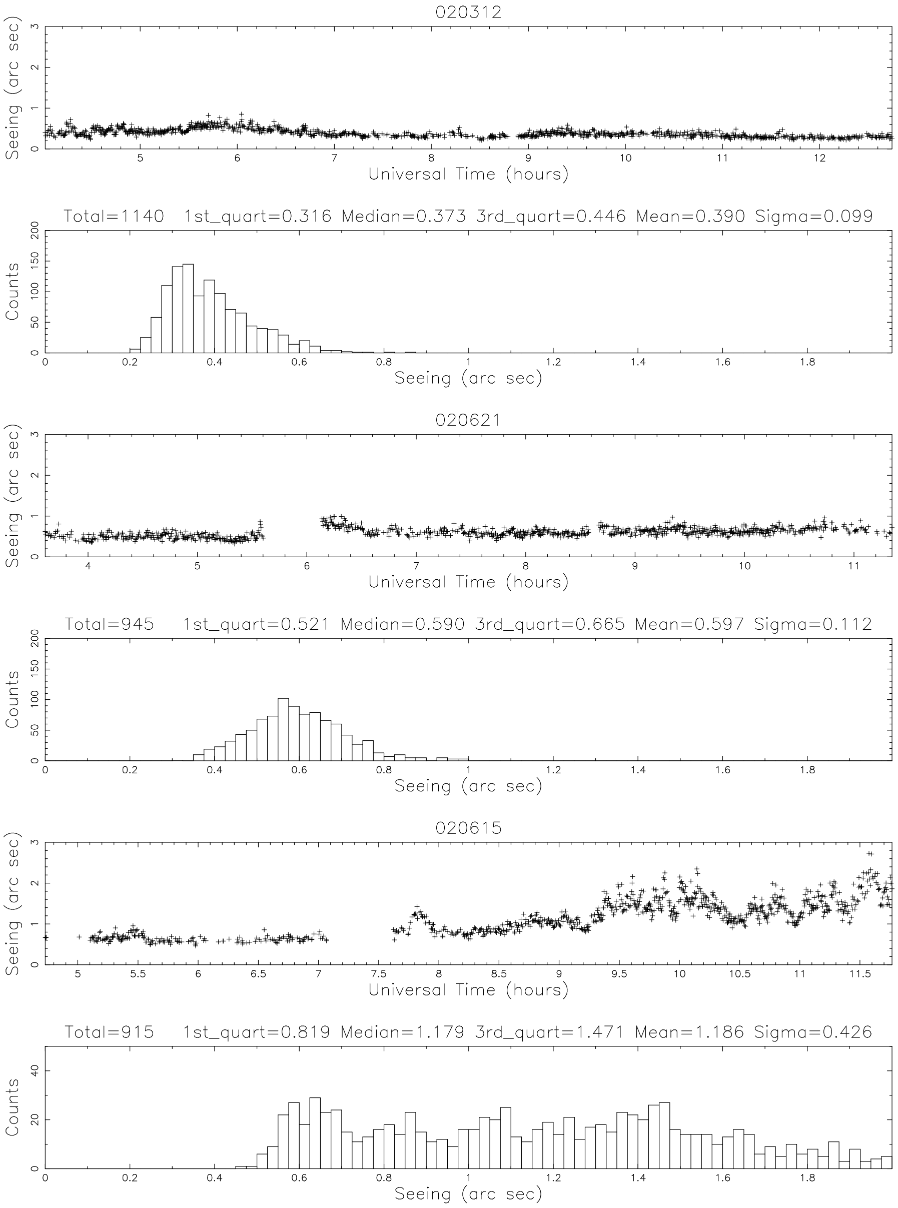

Fig. 2. Examples of observed nights with good, average and poor seeing.

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Muñoz-Tuñon (1995). The instrument we used consists of a 20 cm Schmidt-Cassegrain telescope (CELESTRON) on an equatorial mount with automatic guiding capabilities, a diaphragm with two 60 mm diameter apertures with their centers separated by 140 mm, an optical wedge in one of these apertures, an intensified CCD camera (LHESA's LH750EIA) and a PC compatible computer equipped with a frame grabber.

The optics of the instrument produces two images of the same star. This information is captured by the camera and then sent to the computer via the frame grabber. By computing the variance of the differential motion of the two images of the same star, in both the parallel and perpendicular directions with respect to the apertures, two independent values of seeing are obtained. The advantage of this differential technique is that the erratic motions of the images produced by the instrument (due to tracking errors, wind shaking and bad focusing among other things) are canceled out.

The instrument is located at the same site where we had previously used the Carnegie Monitor (Echevarría et al. 1998). The DIMM telescope

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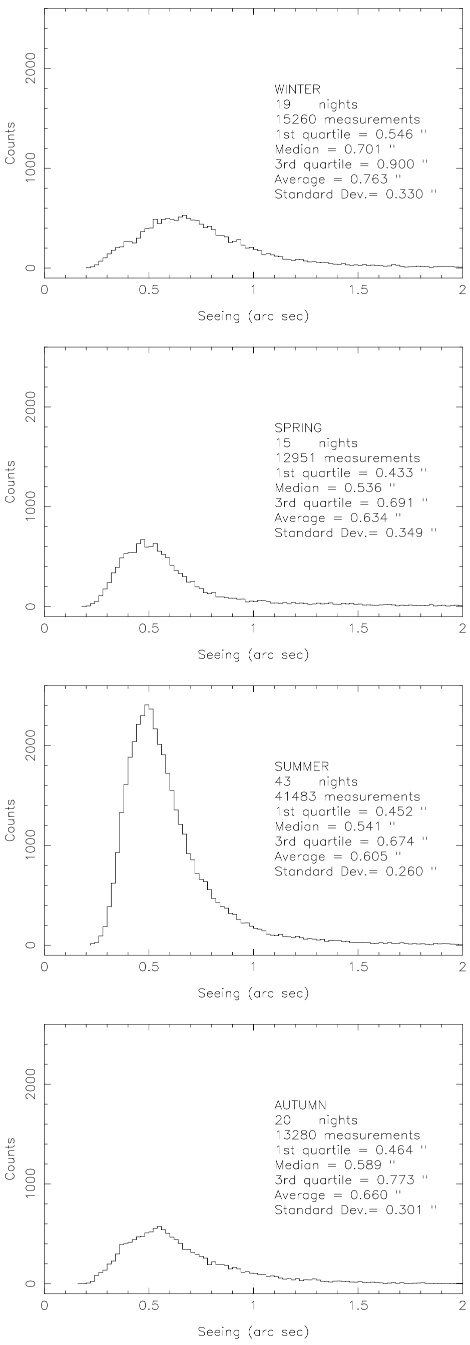

Fig. 3. Seasonal distribution of the measurements.

and part of the electronics are installed at the top of a concrete pedestal that places the diaphragm of the telescope 8.3 m above the ground. The computer and the rest of the electronics are inside a small hut, well detached from the pedestal.

Each data point comes from the processing of a sequence of 200 6-ms exposure time frames. Including the associated processing time, we thus obtain a pair of air-mass-corrected seeing measurements every 14 seconds.

A total of 90 observation nights were carried out from August 18, 2000 through October 14, 2002. In addition, with their kind permission, we included 7 extra nights observed by Conan et al. (2002) in order to improve our seasonal coverage in Autumn. Each data point was calculated as the average of the simultaneous longitudinal and transversal seeing measurements. When these values differ by more than 12% – the expected relative error for the DIMM Muñoz-Tuñon, Vernin, & Varela (1997)– the data point was discarded.

3. THE SEEING DISTRIBUTION

The median seeing values for each of the 97 individual nights, folded with the orbital period of the Earth, are shown in Fig. 1.

The sample is not evenly distributed: there is a noticeable gap in May and a clustering in August, but we do not expect any large deviations from the overall results during the poorly sampled months. It can be seen that there are only six nights in the whole survey with median seeing above one arcsec: four in March, one in June an additional one in September. A short discussion on the seasonal seeing distribution will be given in §5.

4. NIGHTLY SEEING STABILITY

In order to illustrate the seeing stability during any given night, we have plotted the data points as a function of time for three nights with excellent, good and poor seeing, each one together with their corresponding histogram. These are shown in Fig. 2. The upper pair of graphs corresponds to observations made during the night of March 13, 2002 which lasted 8.8 hr. The median value yields 0.37 arcsec, with measurements as low as 0.2 arcsec. The middle graphs correspond to the night of June 21, 2002 with 7.8 hr of data. Here the median seeing is 0.59 arcsec.

At the bottom of the figure we show an example of bad seeing observed four nights after the previous example. This run lasted 7 hr and has a median value of 1.18 arcsec. In this last example the seeing started with a mean value of ~0.6 arcsec and steadily increased throughout the night, reaching values greater than 2 arcsec.

These examples are not unique. In particular, other excellent seeing nights were measured. These results are comparable or slightly better than previous ones obtained for single nights, as is the case in the example shown for the night of May 22, 1993 by Echevarría et al. (1998), where simultaneous STT and Carnegie observations yield a median of 0.43 arcsec for an 8 hour run during a very stable night.

5. SEASONAL DISTRIBUTION OF SEEING

Figure 3 shows the seeing distribution as a function of season. Although the number of nights available are not well distributed for a good statistical seasonal analysis, we can point out the following: 1) Spring, summer and autumn are excellent seasons with a median seeing around 0.56 arcsec; 2) Winter, with a median of 0.70 arcsec, is not as good. 3) If we calculate the averages of all the seasons we obtain a year round median, first and third quartiles of 0.59, 0.47 and 0.76, respectively. Note that these values are slightly higher that those of Fig. 2 but, we believe, are more representative of the real median yearly seeing. These are the values quoted in the abstract.

If we compare the seasonal results with those of Echevarría et al. (1998), see their Fig. 19, we have to take into account many parameters like the number of observed nights, number of observations during a given night, method of observation and reduction, height of the instrument, etc. On top of this, in both papers, we are dealing with a limited number of nights, so we can not make a strong comparison, but rather point out only to general trends. In the case of winter we obtain similar results with a median seeing around 0.70 arcsec. Although for spring, summer and autumn we get better results in this paper, one has to be aware that the STT was 3.8 m above the ground, while the DIMM was at a height of 8.3 m. From the MTA results by Echevarría et al. (1998) (see their Fig. 12) we know that the seeing improves about 0.06 arcsec from 4 to 8 meters, so we should expect, in general, better results in the present work.

6. CONCLUSIONS

From the present two-year DIMM program to monitor the atmospheric turbulence at the site of the Observatorio Astronómico Nacional in San Pedro Mártir we conclude that: a) the seeing has a median of 0.59 arcsec and a first quartile of 0.47 arcsec; b) it is not uncommon for the seeing to remain very stable for whole nights, under excellent conditions, the best results yield a median with 0.37 arcsec during nearly nine hours of continuous observations; c) there is a substantial seasonal difference between spring-summer-autumn (median around 0.56 arcsec) and winter (median of 0.70 arcsec). Although this last result might be due to poor statistics, it is compatible with previous studies of the site.

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