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San Pedro Mártir: Astronomical Site Evaluation (México, D. F. and Ensenada, B. C., México, April 3-4, 2003)
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FOUR YEARS OF METEOROLOGICAL MEASUREMENTS AT SAN PEDRO MÁRTIR OBSERVATORY

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RESUMEN

Se presentan datos climáticos adquiridos durante los últimos cuatro años con la estación meteorológica del telescopio de 1.5 m del Observatorio Astronómico Nacional en San Pedro Mártir. Las temperaturas medidas están en el intervalo de $-15°$ C to $20°$ C. La humedad relativa muestra una dependencia con las estaciones climáticas y los valores medidos tiene una alta dispersión especialmente durante las noches de verano. Valores medidos de la presión atmósferica están en el intervalo de 550 a 565 mmHg. La mediana para la rapidez del viento es 3.9 m/s durante el día y 5.3 m/s durante la noche.

ABSTRACT

We present weather data acquired during the last four years with the meteorological station of the 1.5 m telescope at the Observatorio Astronómico Nacional at San Pedro Mártir. Measured temperatures are in the range of $-15°$ C to $20°$ C. The relative humidity shows a seasonal dependence although with high variations in short scale times, specially during the summer nights. Measured pressure values are in the range of 550 to 565 mmHg. The median values for wind speed are 3.9 m/s during the day and 5.3 m/s during the night

Key Words: **METEOROLOGY — SITE TESTING**

1. INTRODUCTION

Since the end of 1998 we have been regularly gathering meteorological information from the weather stations installed at the 1.5 m and 0.84 m telescopes at the Observatorio Astronómico Nacional (OAN) at San Pedro Mártir. These stations were designed and built in-house and include devices for measuring atmospheric pressure, relative humidity, outdoor ambient temperature, telescope primary mirror temperature, and the temperature gradients between the primary and secondary mirrors. A complete description of these stations is given by Michel et al. (2001). In this contribution we present the meteorological data gathered at the 1.5 m telescope during the last four years.

2. RESULTS

The meteorological variables are measured continuously (∼200 measurements for each sensor every minute) and every minute the mean values and standard deviations are written into daily data files. An example of the data taken is presented in Figure 1. These graphs correspond to measurements carried out on February 17, 2003. The basic statistics for each variable are shown at the top of each graph. In the fourth graph the indoor temperature of the telescope building is displayed. The dot-dash

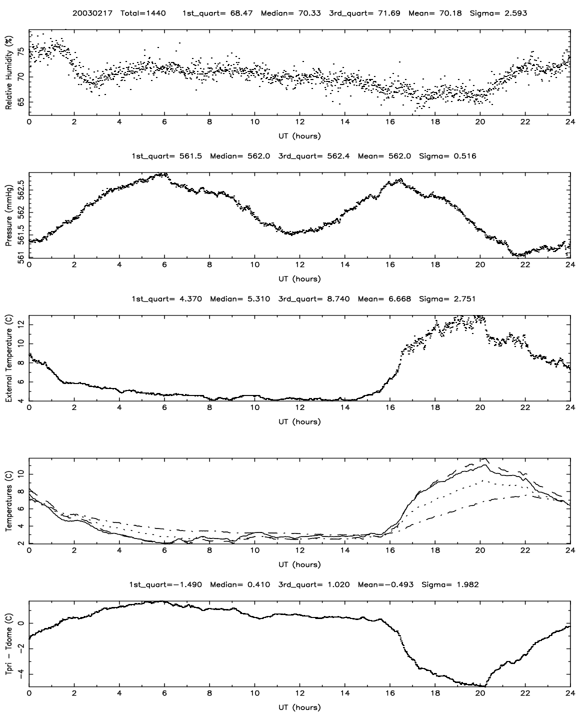

Fig. 1. Example of the data taken with the 1.5 m meteorological station. From top to bottom: Relative humidity, pressure, outdoor ambient temperature, telescope temperatures, and temperature gradient between the primary mirror and the dome.

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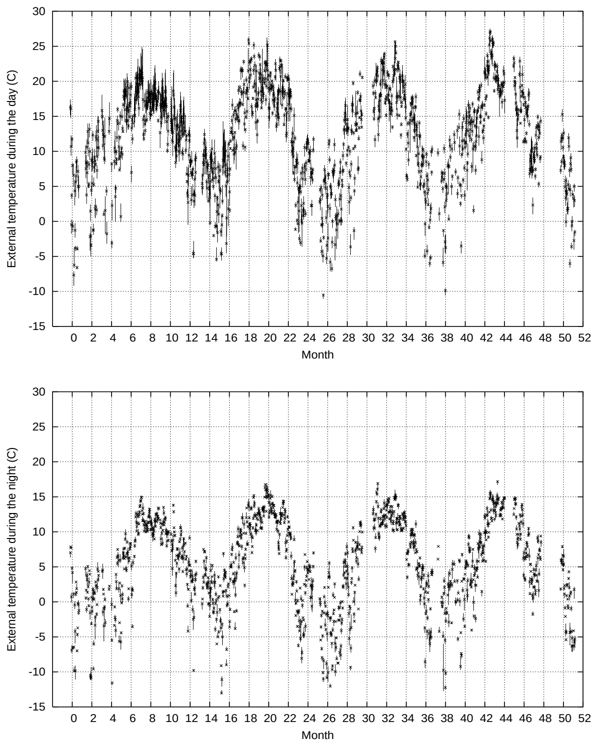

Fig. 2. Daily median outdoor ambient temperature.

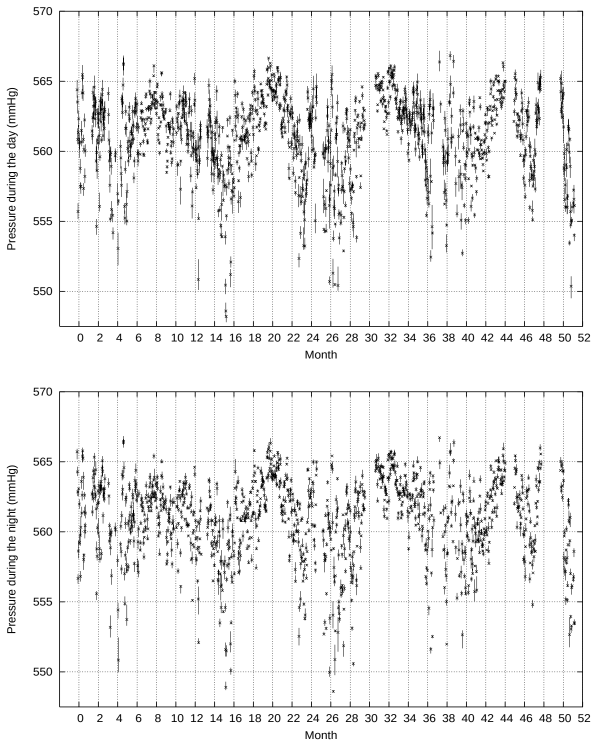

Fig. 3. Daily median atmospheric pressures.

line corresponds to a sensor in thermal contact with the primary mirror. Three additional probes are installed along the telescope supporting structure, all of them measuring the ambient temperature: one is some 30 cm above the primary mirror (dotted line), another (dashed line) is located at the height of the secondary mirror, the third one is in between these two at about 1 m above the primary mirror (solid line).

One of the most important parameters is the temperature gradient between the primary and secondary mirrors. This is shown in the bottom graph of Figure 1. It can be seen that it takes a long time for the primary mirror to dissipate the heat accumulated during the day and reach thermal equilibrium with the surrounding air.

2.1. *Outdoor Ambient Temperature*

Outdoor ambient temperature measurements between November 1998 and March 2003 are plotted in Figure 2. Since there is a different behavior during day and night in most of the meteorological parameters, we present both cases separately. Each point represents the median of all the measurements during six hours. Between 17^{h} and 23^{h} UTM for the day and between 7^{h} and 13^{h} UTM for the night. The bars represent the first and third quartiles.

Seasonal dependence of temperature is clearly visible with minimum temperatures of $-13°$ C about the end of February and maximum temperatures of $25°$ C in July. It can also be seen that the nights are $\sim 10°$ C colder than the days during the whole year.

2.2. *Atmospheric pressure*

Measurements of atmospheric pressure are plotted in Figure 3. There is no noticeable difference of pressure during day and night. It basically varies between 550 and 565 mm-Hg and tends to drop in winter when snow storms move into the region.

2.3. *Relative Humidity*

Figure 4 shows the measured relative humidity as a function of time. To clarify its behavior data has been separated in night-time and day-time data. A clear seasonal pattern is obvious from this Figure, although higher and more frequent values of relative humidity are measured during the summer. Measured values of the relative humidity show a great dispersion with the larger variations found during the night.

2.4. *Thermal gradients*

Measurements of the thermal gradient between the primary mirror and the dome are shown in Figure 5. Due to its large thermal inertia, the primary

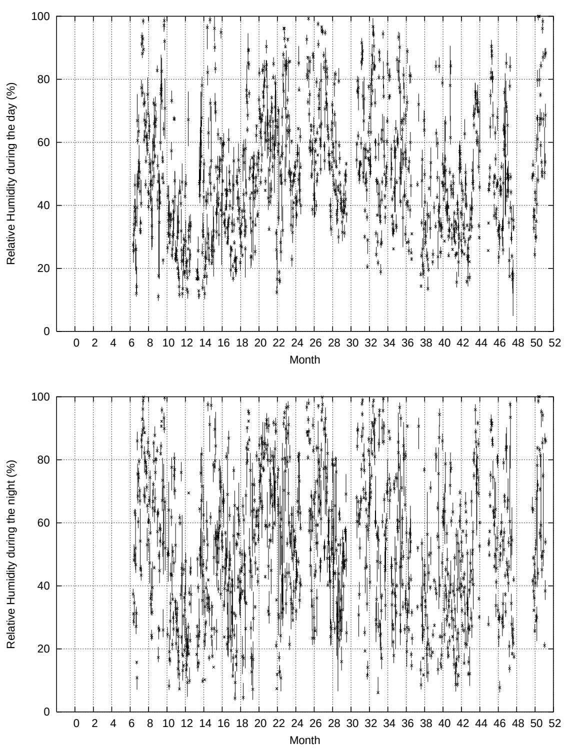

Fig. 4. Daily median relative humidity.

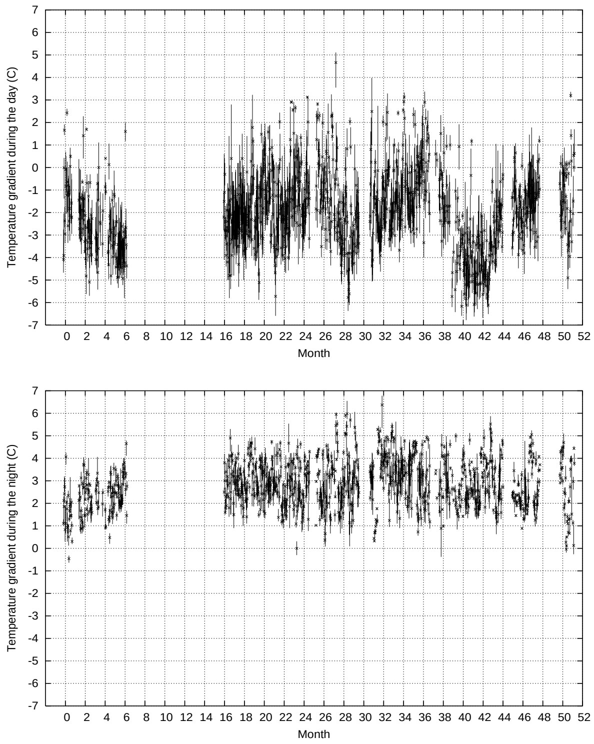

Fig. 5. Daily temperature gradient between the primary mirror and the dome.

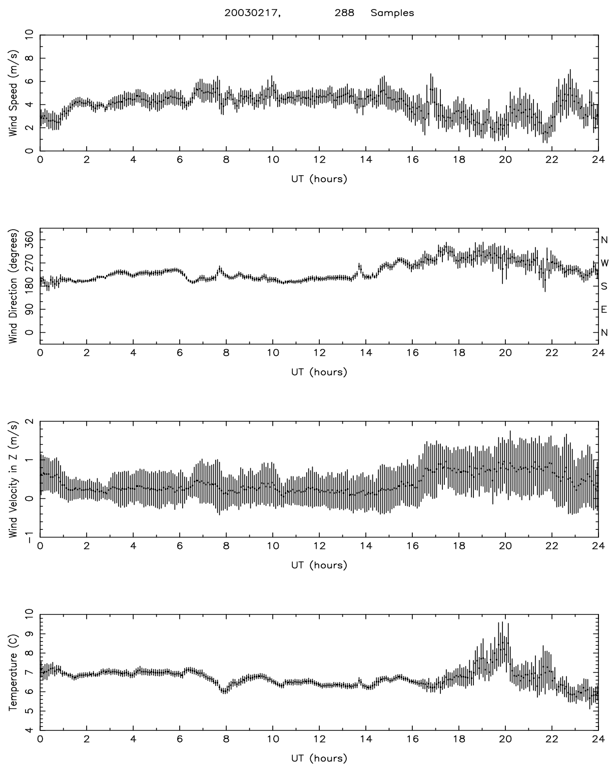

Fig. 6. Measurements with the sonic anemometer during the whole day of February 17, 2003.

mirror is always colder than the dome air during the day, but is substantially warmer at nighttime ($\sim 3^\circ$ C hotter). In this circumstance, cells of warm air will rise from the primary mirror, generating turbulence and thus producing image degradation. The temperature measurements indicate that these cells may be confined to some 50 cm above the primary mirror. Beyond this point the temperature gradient in the dome is practically zero. This pattern occurs during the whole year. Remarkably, the temperature difference between the primary mirror and the dome air is always within the same range regardless of the dome temperature.

2.5. *Wind direction and velocity*

Since the end of January 2002 we have been able to collect data from a ultrasonic anemometer (Hiriart et al. 2001) installed at the selected site for the Mexican Optical-Infrared Telescope. This anemometer, model USA-1 from Metek company, is capable of measuring wind speeds in three directions and is placed $\sim$10 m above the ground. A reading is taken every second. Figure 6 presents this anemometer's measurements for the same day as in Figure 1. Each point represents the average of 300 measurements

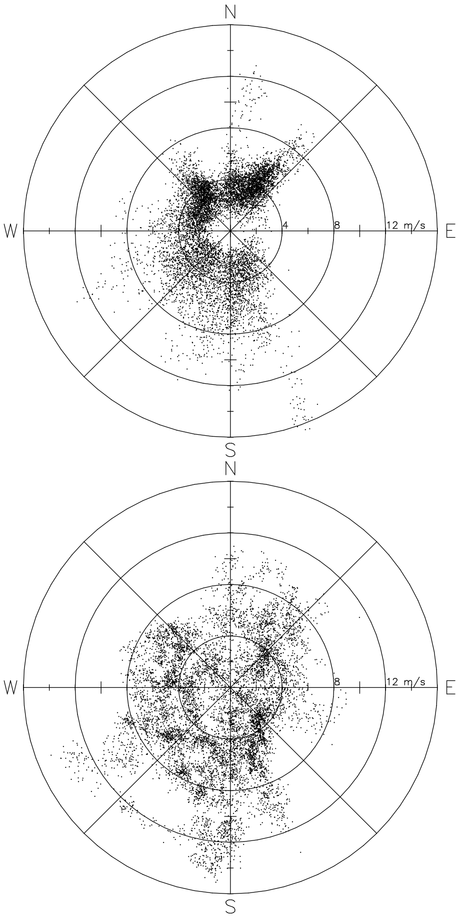

Fig. 7. Horizontal wind velocity during the day (top) and during the night (bottom). Each point represents the average in 5 minutes.

taken every 5 minutes. The bars represent a dispersion of one standard deviation. Wind speed and direction for the horizontal component is shown in the first two graphs while wind velocity in the vertical direction is shown in the third graph. Sonic temperature is shown in the graph at the bottom.

Figure 7 shows the measurements acquired during 150 days between February 2002 and February 2003 while Figure 8 shows the speed distributions of the horizontal component. Because of technical problems it was not possible to measure continuously the whole year but from these data it can be seen, among other things, that: 1) wind speed and direction tend to be more stable during the day; 2) the wind almost never blows from the East during the day, and; 3) Winds tend to be stronger during

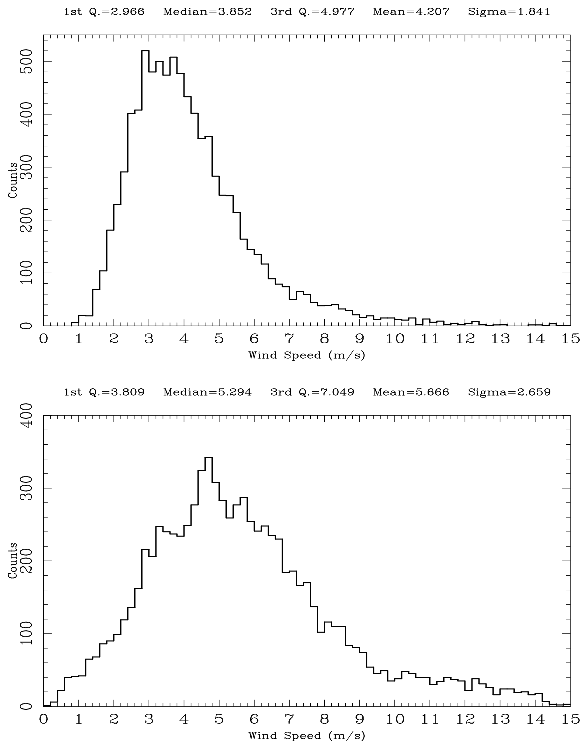

Fig. 8. Distribution of wind speed during day (top) and night (bottom).

the night. The median values for the wind speed are 3.9 m/s during the day and 5.3 m/s during the night.

3. CONCLUSIONS

Four years of weather data from the Observatorio Astronómico Nacional have been presented. The results in this paper corroborate previous meteorological measurements made at the site. The paper also presents recent information about wind data that complement the night-time wind measurements reported by Echevarría et al. (1998).

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