Astro-meteorological characterization of CASLEO sites: technical description and evaluation of the data series

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Resumen / A través de una colaboración iniciada entre astrónomos, meteorólogos, e ingenieros de la FCAG y el CASLEO, se ha encarado un proyecto de caracterización astrometeorológica de los sitios del Complejo Astronómico El Leoncito, particularmente el Cerro Burek, donde se encuentran instalados varios telescopios por convenios con instituciones extranjeras. En esta primera etapa presentamos una descripción técnica del instrumental utilizado, y la evaluación de los datos disponibles, con series que alcanzan los 16 años en el caso de las variables meteorológicas. Sobre esta base se está elaborando un plan de análisis que permitirá establecer las propiedades de los sitios, con vistas a la instalación de nuevos instrumentos astronómicos.

Abstract / A collaboration started between astronomers, meteorologists, and engineers of FCAG and CASLEO is developing a project with the aim of characterizing the astro-meteorological conditions at the "Complejo Astronómico El Leoncito" sites, particularly the "Cerro Burek" summit, where several telescopes have been installed through agreements with institutions of different countries. In this first stage, we present a technical description of the instruments and an evaluation of the available data, which —in the case of meteorological variables— comprise time-series spanning 16 years. We are developing a plan to analyze this database, with the goal of establishing the sites' astro-meteorological conditions, pointing to the future installation of new astronomical instruments.

Keywords / site testing — atmospheric effects — light pollution

1. Introduction

Selecting a site suitable for the installation of telescopes and scientific astronomical instruments, in general, requires precise knowledge of its meteorological conditions, as well as of Astronomy related variables, such as seeing, night-sky brightness, opacity, etc. Short-term (few years) campaigns may be misleading, due to climate variability. Thus, long and homogeneous time-series of meteorological data are needed to achieve a reliable climatological characterization of any site (Aguilar & Llanso, 2003), particularly when substantial investment is planned.

In this work, we present a short description of the meteorological and sky-quality instruments operating at the "Complejo Astronómico El Leoncito" (CASLEO, San Juan, Argentina), and we evaluate the usefulness of the data series to achieve a thorough characterization of the sites. As an illustration, we present preliminary results involving different meteorological variables measured at Cerro Burek, which have an impact on the quality of astronomical observations.

2. Instruments

The following meteorological and sky-quality assessment instruments are currently installed (and taking data) at CASLEO:

- Davis Vantage Pro2 meteorological station (wired): HSH* site (Cerro Burek), data registered since Jul/2005 with 30 min cadence. It has an integrated set of sensors, including: anemometer, rain collector, temperature, humidity, solar radiation, and UV radiation sensors.
- Davis Vantage Pro2 meteorological station (wireless): JS** site, data registered since Mar/2018 with 30 min cadence and 1 min cadence starting Apr/2018. Similar sensors to the previous item.
- Cloud Sensor II from Boltwood Systems Corporation, HSH site, data registered since Jun/2011. The cloud sensor is a fundamental device in remote observation. It allows monitoring of atmospheric conditions that can affect astronomical observation and the safety of astronomical instruments. It detects sky cloudiness, rain and snow, daylight, and measures ambient temperature, wind speed, and humid-

*HSH: Helen Sawyer Hogg 0.6 m Telescope
**JS: Jorge Sahade 2.15 m Telescope

Poster contribution

ity. The Cloud Sensor detects the presence of clouds in an indirect manner. It measures the sky temperature by sensing the infrared radiation from the sky. Some other parameters are also sensed in an indirect way. The sensor has a gold finger with a power heater and a fingertip temperature sensor, which estimates the wind speed by determining how cold the finger is.

- Cloud Sensor II from Boltwood Systems Corporation, JS site, data registered since Sep/2019. Similar sensors to previous item.
- Sky surface-brightness sensor *SQM-LE* (Sky-Quality Meter – Lens Ethernet), JS site, data registered since Dec/2011. Data are shown as visual magnitudes per square arcsecond.
- Differential Image Motion Monitor (DIMM) for seeing measurements, JS site, up to Sep/2018 – HSH site, since Nov/2019. Built by CASLEO staff using a Celestron catadioptric 11″ telescope.

Figure 1: Sensors of the *Davis Vantage Pro2* meteorological station installed at Cerro Burek.

All instruments are fully automated, except for the DIMM, which requires an operator to point the telescope to a selected (bright) star, and to start/end the observations.

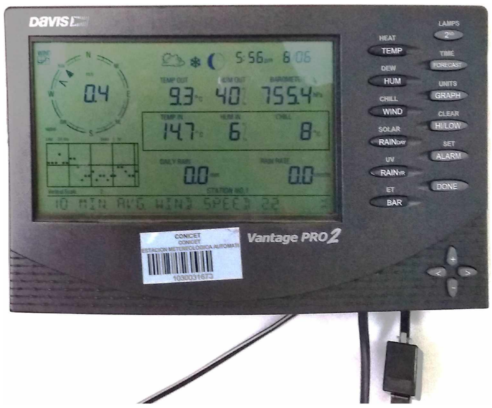

Figure 2: Console of the *Davis Vantage Pro2* meteorological station installed at Cerro Burek.

Here we present preliminary results from the 16 year-long (Jun/2005-Jun/2021) data series collected with the meteorological station at the HSH site (Figs. 1 and 2).

3. Results

Fig. 3 shows the daily mean of wind intensity. In general, the wind is more intense and presents higher variations during daytime than at night. The mean wind intensity during the day hours is maximum from October to December (around 35 km h^{-1}), while the largest variability takes place in winter and spring. At night, wind intensity and its variability do not show significant changes throughout the year. However, between May and October several extreme values higher than 60 km h^{-1} are measured. Mean values remain around 22.5 km h^{-1}.

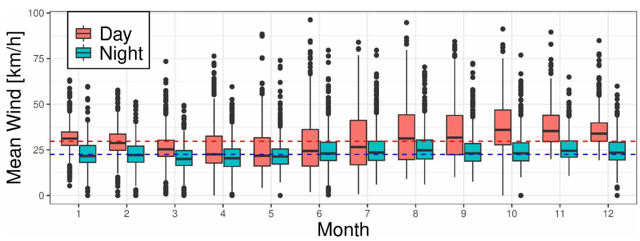

Figure 3: Boxplot of daily mean wind intensity (2005-2021); light-red: day, green: night. Thick horizontal lines show the medians, while colored boxes include values between percentiles 25 ($p25$) and 75 ($p75$). Vertical lines show ranges of values between $\pm 1.5\,(p75 - p25)$ of the median. Black dots show extreme values. Dashed lines show the median of the medians for daytime (red) and night-time (blue). Units are km h^{-1}.

Fig. 4 shows the thermal amplitude during daytime and at night. The highest mean values are registered during daytime along the warmer months. At night, no relevant changes of the thermal amplitude are observed, although the highest thermal amplitudes are observed in the intermediate seasons (autumn and spring). On the other hand, throughout the whole year, extreme values of the thermal amplitude are registered at night, while this behavior is not observed during daytime. The mean of the diurnal medians is 11°C, while at night the mean value is 6°C.

The behavior of dew point depression is shown in Fig. 5, where low (high) values indicate more (less) air humidity. Throughout the whole year, mean values are higher during daytime than at night, indicating a higher presence of relative humidity at night. Particularly, December, January, February, and March show the minimum mean values, and hence the larger values of nighttime humidity. On the other hand, winter months (June – August) present the driest nights.

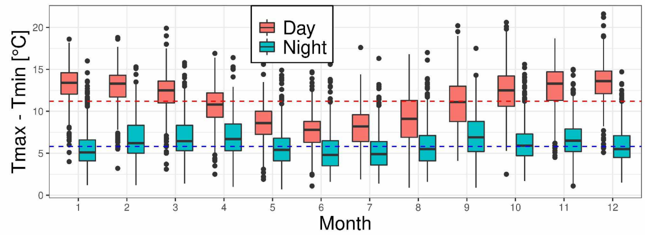

Figure 4: Same as Fig. 3 but for the thermal amplitude (maximum temperature – minimum temperature). Units are Celsius degrees.

Daily precipitation (> 1 mm) is shown in Fig. 6*a*. In general, low precipitation values are registered all year long. The minima of mean precipitation —both for day and night hours— take place during the colder months, while the maxima take place between December and March. The mean of the medians shows that there is no significant difference between daytime and nighttime mean precipitation (both about 3 mm). Regarding the monthly percentage of days with precipitation (Fig. 6*b*), it can be seen that the months showing higher percentage are those corresponding to the warm season (December – March); however, the percentage of days with precipitation is on average < 10%. From April to October, the percentage of days with precipitation is practically non-existent.

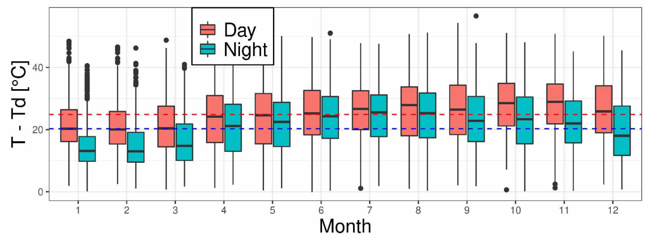

Figure 5: Same as Fig. 3 but for the dew point depression (temperature – dew point temperature). Units are Celsius degrees.

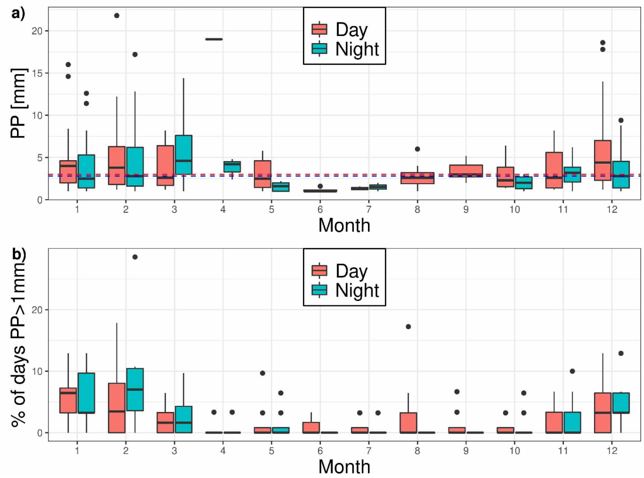

Figure 6: Same as Fig. 3 but for *a*) precipitation (mm), *b*) monthly percent of days with precipitation greater than 1 mm.

4. Conclusions and future work

CASLEO has valuable series of meteorological variables and records of astronomical conditions, which can be used to extract information aiming at a consistent and detailed characterization of the sites within the Astronomical Complex. Previous studies, based on smaller data-sets, can be found in Martinis et al. (2013); Cavazzani & Zitelli (2013); Aubé et al. (2014); Poblete & Escribá (2020). The present work is the first step towards a thorough study of CASLEO sites, involving different aspects which impact on astronomical observations. Future work will encompass:

- installation of particulate matter sensors (through an agreement with San Juan government) and other meteorological sensors (wind gust, etc.);
- analysis of meteorological conditions (mean conditions and weather change);
- determination of image quality and its temporal evolution, through the analysis of data taken with the DIMM instrument installed at Cerro Burek;
- quantitative determination of the night-sky brightness (from SQM data), and its evolution considering the impact of light pollution;
- study of correlations between astronomical conditions at the sites (using data obtained with the mentioned sensors and/or observational data gathered with the various telescopes) and contemporary measured meteorological variables.

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