Application of climatological monitoring for the candidate CTA site at Izaña (Tenerife)

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Abstract. The location of Izaña (Tenerife, Canary Islands) has been proposed for hosting the Cherenkov Telescope Array (CTA). To support the site-testing campaign, we obtained climate normals from the 10 year long series recorded at Izaña by the atmospheric Observatory (CIAI), we have also compared the wind regime with a simultaneous 10 year database at the neighbouring astronomical site (OT) and with the available simultaneous preliminary wind data for the proposed CTA location. The results show a smooth temperature profile with sporadic but moderate extremes and a low daily (24 h) temperature range. Rainfall is extremely sporadic (287 mm/y) with low intensity. Wind speed and gusts show high stability and moderate values and dispersions. The lowest winds are in the summer. Speed episodes greater than 100 km/h are very rare and 11 data points have been recorded with gusts above 150 km/h over the 10 years. The dominant wind direction is WNW. There is an excellent correlation for wind speed between the CIAI and OT, with a slight difference in the dominant wind direction (N versus WNW). The wind data recorded directly at the CTA location also show very good correlation in trends, the wind speed at the CTA site being ≈ 24% lower. The dominant wind direction at the CTA site is NW.

1. Introduction
The Izaña summit (≈2400 M.S.L.), on Tenerife (Canary Islands, Spain) hosts both the Teide astronomical Observatory1 (OT) and a meteorological observatory, the Izaña Atmospheric Research Centre2 (CIAI). The area has been proposed as a candidate site for the Cherenkov Telescope Array in the northern hemisphere3 – CTA-North (see Fig. 1 for the location details). To support the CTA site-testing campaign, we have obtained climate normals over a ten-year period. Ten year studies are recommended for providing an accurate picture of a location’s climatic conditions as they minimize distortion in climate series resulting from climate change and other trends [1]. The results presented here have been extracted from an extensive report that was provided to the CTA site selection team.

1 www.iac.es/eno.php?op1=3&klang=en
2 www.izana.org
3 www.cta-observatory.org
2. The stations

The meteo station at CIAI was selected on the basis of its excellent data quality. The CIAI is part of the Spanish Agencia Estatal de Meteorología (AEMet). The selected station is part of the WMO with index 60010. The sensors are installed at the top of a 10 m mast.

Furthermore, to analyse possible local inhomogeneities, wind regime comparisons have been carried out using a station at the astronomical site (OT), ≈1.5 km away. The station selected supports the operation of the GONG astronomical facility. The sensors are located on a 7 m mast.

While this work was being carried out, the CTA team set up their own weather station on a 10 m mast at the exact location of the candidate site, some 5 km from the CIAI. In order to extend the parameters obtained for Izaña to the CTA site, a preliminary wind comparison with the available CTA data was carried out.

3. Data at CIAI

The data, except for precipitation, were recorded with an automatic weather station (AWS) at a frequency of 1/10 min, suitable for the separation of night- and day-time analysis. Precipitation was obtained from the non-automated series as hourly cumulative by observers. All central tendency estimates have been calculated as median values in order to look for statistical

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www.aemet.es/en/

World Meteorological Organization.

Global Oscillation Network Group, http://gong.nso.edu/sites/elteide.shtml
robustness in the results. The median absolute deviation (m.a.d.)\(^7\) has been used for dispersions. Additionally, the mean and standard deviation are also given in the figures. Special care has been taken to avoid including periods where we estimated sampling errors above 10%. Statistical homogeneity was assumed for the series. No inconsistencies of note were found when the data were explored for the presence of outliers. Wind data were rejected when wind speed equalled 0 simultaneously with temperatures below 2\(°\)C (frozen anemometer effect).

The database includes temperature, precipitation, relative humidity, wind speed (10 min averages) and gusts.

4. Temperature
Temperature is dominated by a smooth profile, with very sporadic extreme events, and a low temperature range (the difference between daily max and min). Figure 2 summarizes the temperature statistics at the CIAI. The median temperature is 9.6\(°\)C and the absolute minimum recorded is \(-7.5\)\(°\)C. Temperature is over 0\(°\)C for 95% of the time. The temperature Range is small, with a median value of \(\approx7\)\(°\)C and is highly stable throughout the year.

5. Precipitation and Relative Humidity
Table 1 summarizes the precipitation as yearly cumulative. Median rainfall at the CIAI is \(287\pm158\) mm/y. This value corresponds to an environment classified as arid and semi-arid\(^8\). The precipitation is even less frequent and intense during night time. Figure 3 shows the precipitation intensity in mm/h. The precipitation episodes correspond to singular events, typically less than 1 hour, that rarely reach a ‘heavy’ level. The no precipitation stage corresponds is applicable to 96% of the data. The precipitation is concentrated between October and March with noticeable minima in December and January. Snow and hail occur 11.7 and 1.1 days/year respectively, mainly in February and March, with some episodes in autumn and spring.

\(^7\) The m.a.d. is a robust estimator for dispersion. For normally distributed samples, 50% of the sample falls in median\(\pm\)m.a.d. \(=\) m.a.d. \(\approx\) \(1/2\) \((P_{75} – P_{25})\) and \(1\sigma \approx 1.4826\) m.a.d.

\(^8\) Extract from the Arid Zone classification based on rainfall of the FAO (Food and Agriculture Organization of the United Nations)[2]:

| Arid Zone         | Rainfall Range |
|-------------------|----------------|
| Hyper-arid zones  | < 100 mm/y     |
| Arid zones        | 100 – 300 mm/y |
| Semi-arid zones   | 300 – 800 mm/y |
The relative humidity is low and follows the precipitation cycle. The median value is 29% and the 25th percentile is 15%.

Table 1. Yearly precipitation [mm/year] (total –PR, liquid –PR\textsubscript{liq}– and frozen –PR\textsubscript{froz}).

| [mm/year] | Median | Mean  | m.a.d. | Sigma |
|-----------|--------|-------|--------|-------|
| PR        | 287    | 354   | 93     | 158   |
| PR\textsubscript{liq}  | 209    | 217   | 70     | 125   |
| PR\textsubscript{froz} | 81     | 137   | 40     | 120   |

6. Wind

Figure 4 presents the main results for wind (speed and direction) at the CIAI. Wind speed shows moderate values. The median (22.3 km/h) and the upper percentiles (P95= 52.9 km/h) perfectly allow a safety operation and ensure a low percentage of downtime due to wind for most astronomical installations. Wind speed is \( \approx 12\% \) higher at night. The lowest wind speed values are in summer.

Both wind speed and gust show stability with moderate dispersion and high correlation. Wind gust is \( \approx 30\% \) greater than wind speed and \( \approx 20\% \) more spread. Wind gust does not show significant differences between night and day. In the 10 year period there are only 11 points, concentrated in 4 days, with gusts over 150 km/h.

The dominant direction has a clear component from the WNW, both for speed and gust, with punctual ‘winter south component’ episodes. The most intense wind direction roughly coincides with the predominant wind direction.

7. Wind comparison between CIAI, OT and the CTA

Once we established the climate normals for the CIAI, we compared the wind regime with a simultaneous 10 year database at the OT (the GONG station) and with the available simultaneous data from the CTA site.
7.1. GONG station
Meteo data at GONG are recorded with an AWS at a frequency of 1 min⁻¹. The extent covered by GONG ensures a direct comparison with the CIAI. Unfortunately, no wind gusts are available. The data were also examined and corrected for the presence of outliers and inconsistencies. The GONG 1 min⁻¹ series had to be processed to match the CIAI standard (1/10 min). The smoothing was carried out by grouping the data in 10 min steps and computing the median.

Figure 5 shows the main statistics for GONG wind in comparison with the CIAI series (magenta). Wind speed behaviour is very similar in the two locations with a correlation of 0.85. The GONG wind direction also show a clear dominant direction but ≈ 80° northward from that of the CIAI (N versus WNW).

7.2. CTA station
In order to extend the normal values of the CIAI to the CTA site, a wind comparison was carried out with the first year of available data (December 2012 to January 2014). We have selected only simultaneous data that guarantee a correct comparison. The sampling rate for CTA is 1 min⁻¹, so the data were processed to match the CIAI standard (1/10 min). Figure 6 summarizes the main results at the CTA in conjunction with the CIAI (magenta). There is excellent agreement between the wind speed trends and also for gusts, the wind being generally lower at the CTA. The median wind speed is 15.8 km/h at the CTA and 20.9 km/h at the CIAI, which implies a relative difference of ≈ 24% (the median gust is 21.8 and 27.8 km/h, for the CTA and CIAI, respectively).

The wind speed and wind gust direction coincide at the CTA. The predominant direction at the CTA is NW. The strongest wind direction at CTA is also NW.

8. Final summary
In this article we have presented a brief overview of the analysis carried out in order to study the climate at Izaña (Tenerife). A full text, with the complete information, will be published soon [4]. It is important to emphasize the mildness of the climate as measured for the temperature and precipitation at this height of 2400 m. Also important is the relative homogeneity of the
wind pattern when comparing values at the CIAI with the astronomical observatory (≈1.5 km away) and the CTA candidate site (≈5 km apart).

Acknowledgments
This report made use of 10 years of data recorded by the Spanish Agencia Estatal de Meteorología (AEMet) at the Izaña Atmospheric Research Centre (CIAI) and by the Global Oscillation Network Group (GONG) at Teide Observatory (OT). Additionally, some wind data from the Cherenkov Telescope Array (CTA) astmoscope station at Tenerife were also used for comparison. We are grateful to all these sources for the kind distribution of their data. We particularly thank Pere Lluís Pallé from GONG and Diego Sierra from the IAC Network department. We are also grateful to Terry Mahoney for the language correction of the manuscript. This work was funded by the IAC.

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