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Day time Cloud Cover at Teide Observatory

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Abstract

We have exploited the European Climate Assessment & Dataset series of day time oktas of cloud cover at Izaña Observatory, Tenerife (Spain), to estimate the useful time at Teide Observatory. The data cover a period of 68 years (1933–2000). The useful time, considered as the sum of days classified as clear and partially cloudy, ranges between 94% in summer and 69% in autumn, with an average value of 81%. The clearest month is July and the cloudiest is November.

Keywords: *atmospheric effects, site testing, astronomical data bases: miscellaneous, opacity*

1 Introduction

The portion of sky covered by clouds of any type or height is defined as the cloud cover (CC). The CC plays an important role in climate studies, such as those focusing on the hydrological cycle or the solar radiation balance. Traditional measurements of CC are made by observers and visual inspection as the proportion of the celestial dome with clouds. The proportion is given in eighths or *oktas*. The observation method is described by the World Meteorological Organization (WMO) [6] and takes into account the clouds over the Observatory level, giving equal emphasis to all angular elevations. The records are coded as an integer number between 0 and 8 following table 1 [5]. Table 1 also shows the *day type* classification based on oktas proposed by [1]. This scale classifies the day type as clear (0–2 oktas), partially cloudy (3–5 oktas), or cloudy (6–8 oktas) and is commonly used by different agencies of meteorology.

oktas	meaning	day type
0	completely clear	clear
1	1/10 or less but not zero	
2	2/10 – 3/10	
3	4/10	partially cloudy
4	5/10	
5	6/10	
6	7/10 – 8/10	cloudy
7	9/10 or more but not ten	
8	completely cloudy	
9	sky obscuration other than clouds, such as fog, hindering the estimation	

Table 1: The synoptic scale for recording the total amount of cloud cover (CC) [5] and *day type* classification [1]

For an astronomical observatory, the CC is directly related to useful observing time. The time available for science with a particular facility is also influenced by other factors, each depending on its own features, such as tolerance to wind speed or sky quality requirements for science targets, as well as maintenance and technical downtime [3]. Cloud Cover can be adopted as an independent indicator of the total potential useful time for the site. In this study we consider as useful time the percentage of non-cloudy days; that is, the sum of clear and partially cloudy days.

2 The site

We have analysed 68 years of daily observations of CC recorded at Izaña Meteorological Observatory[1] (IZO). The results are then applied to the Teide (astronomical) Observatory[2] (OT). Both Observatories are separated ∼1.5 km on the summit of Mount Izaña at ∼2400 masl, in the centre of Tenerife (Canary Islands, Spain; see Fig. 1).

Because of their latitude, the strong influence from the Azores high and the cold oceanic stream, the lower troposphere of the Canary Islands exhibits a vertical structure with an almost constant thermal inversion layer (IL). The altitude of the

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[1] IZO belongs to the Spanish Agencia Estatal de Meteorología (AEMet) through the Izaña Atmospheric Research Center (CIAI; http://izana.aemet.es/)

[2] OT belongs to the Instituto de Astrofísica de Canarias (IAC; http://www.iac.es/ot)

Name	Station id	Source id	Lat	Lon	Height	Begin	End	Units
IZAÑA	1388	120743	+28:18:32	-16:29:58	2371m	1933-01-01	2000-12-31	oktas

Description	Observations
Mean daily cloud cover, mean of 7, 13, 18 UT current day	LT is UT+0 in witer and UT+1 in summer Celestial dome visibility $> 99.7\%$

Table 2: Metadata for the station IZAÑA at IZO from **www.ecad.eu**. See [4] for the ECA&D daily data set description.

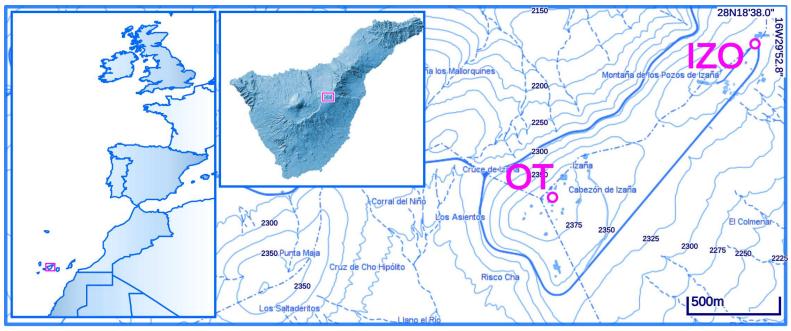

Figure 1: Topographic map of Izaña with the location of IZO and OT. The sites are separated ∼1.5 km. The small maps show the area of interest in Tenerife and the Canary Islands in the Atlantic Ocean.

Figure 2: The *sea of clouds* extends to Tenerife from the neighbouring Roque de los Muchachos Observatory, on La Palma.

IL ranges on average from 800 m in summer to 1600 m in winter, well below the altitude of the IZO and OT [2]. The IL plays an important role in the retention of clouds, conforming an almost flat surface known as the *sea of clouds*, which ensures very low cloud cover at the mountain summit (Fig. 2). The IL also separates the moist marine boundary layer and the dry free atmosphere, inducing very high atmospheric stability above it.

3 Data

The data have been recorded at IZO from 1933 to 2000 (68 years). The CC corresponds to the daily mean of 7H, 13H and 18H UT rounded to the integer (Local Time –LT– is UT in winter and UT+1 in summer). No changes have been recorded in the surrounding environment in the record extension and the visibility of the celestial dome free of orographic obstacles is $> 99.7\%$. The metadata are listed in table 2.

The data were downloaded from the European Climate Assessment & Dataset project[3] (ECA&D). The ECA&D project is an initiative of EUMETNET[4] and forms the backbone of the climate data node in the Regional Climate Centre of the WMO in Europe and the Middle East. The daily data sets compiled by ECA&D are described by [4].

3.1 Data treatment

The data quality is self controlled by ECA&D. The values with okta $= 9$ have been treated as missing and not included. The central tendency estimates have been calculated by means of the average ($\overline{\mathrm{CC}}$) and the standard deviation (σ). For robust statistics, a 20% trimmed sample (10% at both extremes) has been obtained to calculate the robust trimmed mean ($\overline{\mathrm{CC}_\mathrm{r}}$) and σ_r. The data coverages are calculated to the total potential data in the 68 recorded years.

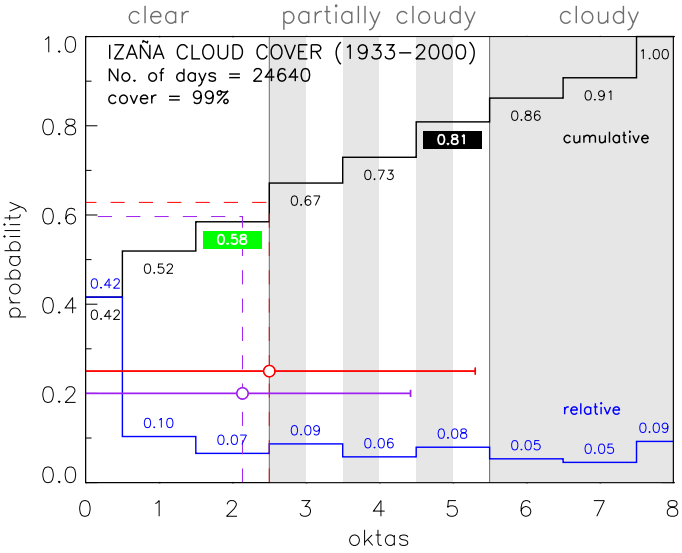

Figure 3: Statistical distribution (cumulative: black and relative: blue) of CC in oktas at IZO. The red circle and error bar are the mean and σ. The dashed red lines are the projection of the mean on the cumulative distribution, with a linear interpolation between the steps. The purple symbols are the same but for a 20% robust trimmed sample (10% at both extremes). The green and black boxes mark the probability of clear and useful time. Useful time is defined as the sum of clear and partially cloudy time.

[3] **http://www.ecad.eu/**

[4] EUMETNET is a grouping of 31 European National Meteorological Services that provides a framework to organize co-operative programmes between its members in the various fields of basic meteorological activities.

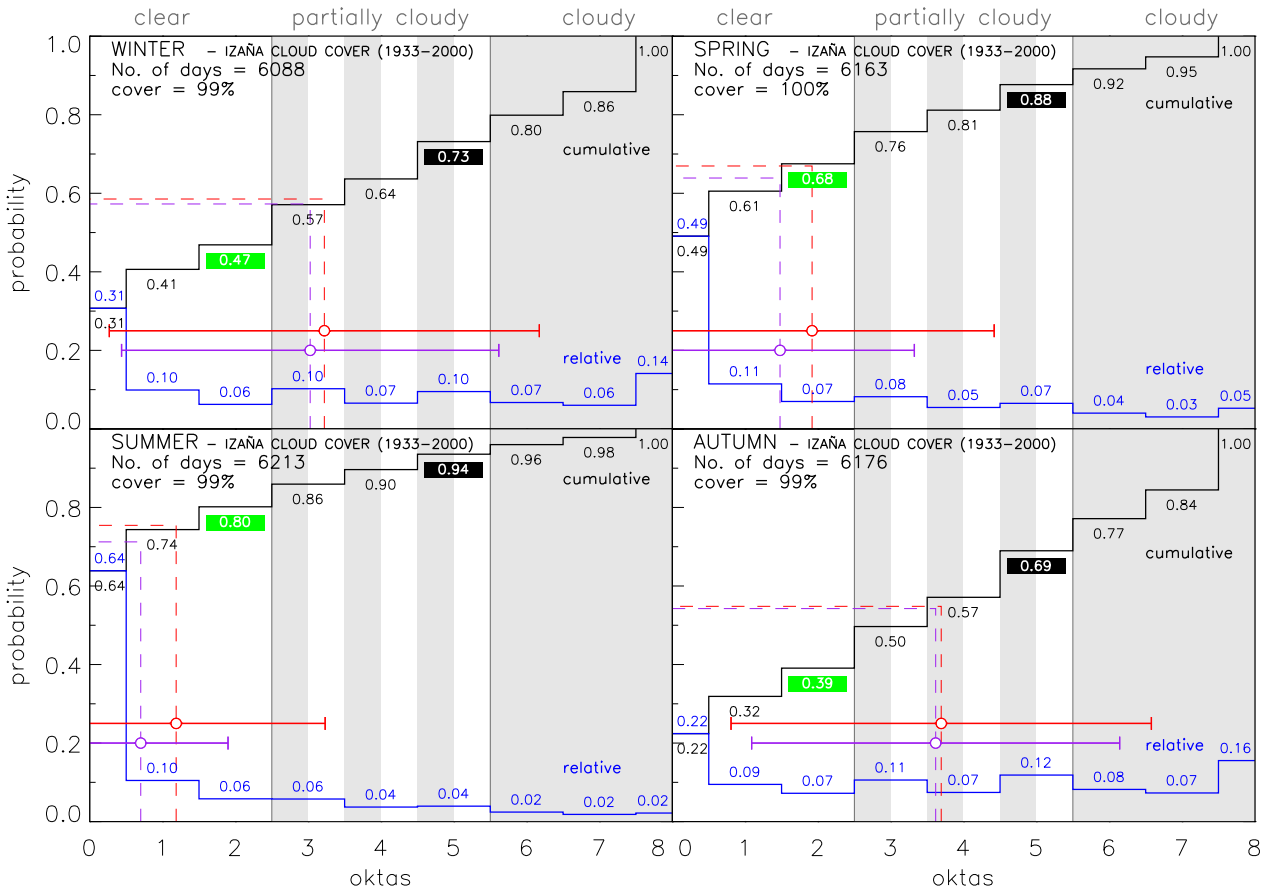

Figure 4: Same description as in Fig. 3, but separated by seasons.

4 Results

Figures 3 and 4 show the total and seasonal statistical distributions, mean, trimmed mean and standard deviation of CC in oktas at IZO. The numerical values are listed in table 3. The CC distribution at IZO is strongly dominated by a 0 oktas scenario (42% of the time, with a summer maximum of 64%), which means an absolutely cloud-free sky during the day. The clear time, according to the synoptic classification given in table 1 is 58% and can be used as an estimate of the percentage of photometric time. Taking the trimmed sample as reference, the average CC at IZO is 2.1 oktas, which also corresponds to clear skies. Apart from 0 oktas, the remaining values show approximately the same probability, which is reflected in a wide σ of 2.3 oktas and in a relatively small difference between the full and the robust statistics. The plots also show the probability of useful time, defined as the sum of clear and partially cloudy time. The diurnal useful time at IZO ranges between 94% in summer and 69% in autumn, with an average value of 81%. Therefore, summer and autumn are the clearest and most cloudy periods of the year, respectively.

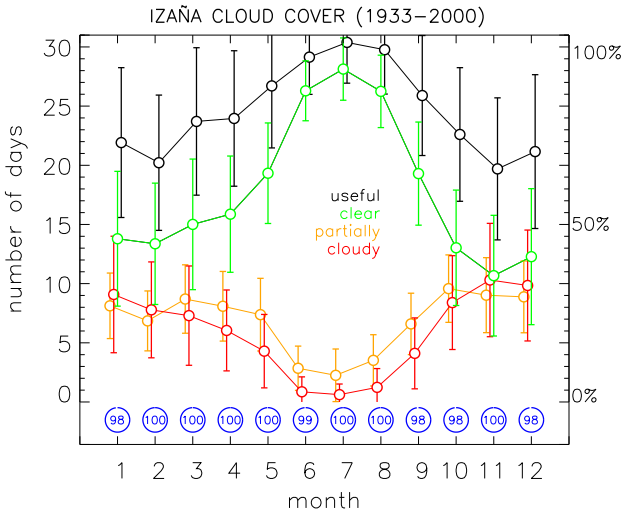

Figure 5: Monthly distribution of clear, partially cloudy, cloudy and useful days per month, based on the oktas series at IZO. Useful time is defined as the sum of clear and partially cloudy days. The monthly results are corrected for the missing days. The blue circle diagrams show the data coverages for each month.

The number of days distributed in the different day types as a function of cloudiness per month is shown in Fig. 5 and in table 4. The table also shows the yearly values. The summer months show an almost 100% of useful time, strongly dominated by clear skies. The clearest month is July and the cloudiest is November. The number of useful days per year is 296 $\pm$ 19, of which 212 $\pm$ 16 are clear days. This result implies $\approx$ 81% of useful days, which coincides with the probability of useful time in Figure 3.

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Season	N (cover)	$\overline{CC} \pm \sigma$	$\overline{CC_r} \pm \sigma_r$
Winter	6088 (99%)	3.2 ±3.0	3.0 ±2.6
Spring	6163 (100%)	1.9 ±2.5	1.5 ±1.8
Summer	6213 (99%)	1.2 ±2.0	0.7 ±1.2
Autumn	6176 (99%)	3.7 ±2.9	3.6 ±2.5
Total	24640 (99%)	2.5 ±2.8	2.1 ±2.3

Table 3: CC statistics by seasons. The total number of days (N) is accompanied by the coverage percentage. $\overline{CC}$ is the mean and σ is the standard deviation (red lines in Fig. 3 and 4). The subscript r refers to the robust mean and σ obtained from a trimmed sample (10% removed at both extremes of the distribution; see purple lines in Fig. 3 and 4).

Month	clear days	p. cloudy days	cloudy days	useful days
Jan	14 ±6	8 ±3	9 ±5	22 ±6
Feb	13 ±5	7 ±3	8 ±4	20 ±6
Mar	15 ±6	9 ±3	7 ±4	24 ±6
Apr	16 ±5	8 ±3	6 ±3	24 ±6
May	19 ±4	7 ±3	4 ±3	27 ±5
Jun	26 ±3	3 ±2	1 ±1	29 ±3
Jul	28 ±3	2 ±2	1 ±1	30 ±3
Aug	26 ±3	4 ±2	1 ±2	30 ±4
Sep	19 ±4	7 ±3	4 ±3	26 ±5
Oct	13 ±5	10 ±3	8 ±4	23 ±6
Nov	11 ±5	9 ±3	10 ±5	20 ±6
Dec	12 ±6	9 ±3	10 ±5	21 ±6
Year	212 (16)	83 (9)	69 (12)	296 (19)

Table 4: Number of clear, partially cloudy, cloudy and useful days per month and per year (see Fig. 5). Useful time is defined as the sum of clear and partially cloudy days.

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