

# Light pollution in the surroundings of Valencia. Anthropic and natural factors

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## Abstract

Although the conservation of a dark sky at first only concerned astronomers, biologists and conservationists soon realized the effects exerted by light pollution on nocturnal wildlife. This degradation increases with cloud coverage, so, as some recent studies have highlighted, it is also necessary to evaluate the influence of clouds on increasing the brightness of the night sky. Furthermore, the effect of the lunar cycle on flora and nocturnal animals may be affected due to excessive lighting.

The variation of the luminance of the sky has been measured at different locations of the city of Valencia and its surroundings, especially in the Turia Natural Park, where we have studied these influences. Moreover we have also evaluated how the Fallas festival lighting is affecting the increase of light pollution.

## 1 Introduction

The problem of light pollution results from various anthropogenic factors such as increasing street lighting, accelerated change of the type of lamps (from high-pressure sodium (HPS) lamps to white light LEDs), installation of inadequate or poorly installed luminaires etc. Some natural factors may also reinforce the problem. The cloud coverage contributes to return down the light excess from the streets. Since the main interest of the authors of this work is to study the increasing incidence of background brightness of the nocturnal sky on natural parks, it is worth knowing how wildlife is affected by the degradation of natural darkness both in clear and cloudy night sky, and what happens on days with and without moon [2, 3, 6].

In Valencia and its surroundings, biologists have noted that nocturnal animals can not distinguish the variable lighting that provides the lunar cycle, because it disappears in the

skyglow caused by the city.

Some recent studies also confirm that light pollution alters the biological rhythms of animals [4]. So far the influence of clouds had not been taken into account, but various studies by [1] and [7], clearly show how pollution is strengthened due to clouds in the vicinity of the city of Berlin while the work of [8] studies these effects in the city of Hong Kong.

Our work aims to make a preliminary study of anthropogenic and natural effects on dark night sky in three very different locations, very polluted Valencia metropolitan area, moderately polluted town of Tavernes, and the Serrania region with nearly pristine skies.

## 2 Instrumentation and methods

Our night sky brightness data were taken using the Sky Quality Meter (SQM) produced by Unihedron. Its Full Width Half Maximum (FWHM) is  $\sim 20^\circ$ . The SQM measures luminance (surface brightness) for a patch of the sky, in units of magnitudes per square arc second ( $\text{mag}/\text{arcsec}^2$ ). We have at our disposal several SQM device units. The SQM-LU-DL allows autonomous collecting of data for weeks without maintenance. We permanently located units in Riba-roja de Turia, in Tavernes de la Vallidigna and temporarily in various places of the Valencian metropolitan area and in the Serrania region. Finally a SQM-LE device, allowing continuous measurement using an Ethernet connexion is located at the Astronomical Observatory of the University of Valencia (AOUV), in Aras de los Olmos.

In addition to the previously mentioned points, we are covering the territory measuring the night brightness with a SQM-LU and a GPS device, both connected to a computer. Some routes in the vicinity of the Turia Natural Park in clear and cloudy nights have been studied looking for differences.

## 3 Loss of the night in Valencia

From March 4 to April 6, 2014 a SQM-LU-DL device was located in the city center of Valencia with three primary goals: knowing if the lunar cycle is visible or not, measuring the influence of the cloud coverage and finally confirming or not the increase in light pollution due to the Fallas festival.

It was found that the night sky brightness is around  $17.5 \text{ mag}/\text{arcsec}^2$  on clear nights while the passage of the moon in the sky of Valencia does not appear to increase or modulate its brightness.

Cloud coverage was the main factor increasing the brightness of the night sky. A clear example of this effect is shown in Fig. 1. The passage of a cloud system above the city on the night of March 25th brightened the sky in more than 3 magnitudes giving values of  $14.5 \text{ mag}/\text{arcsec}^2$ .

Finally the lights illuminating the Fallas festival seem to increase by 0.6 magnitudes the Valencian sky brightness reaffirming our measures taken two years ago from the Calderona Natural Park [5].

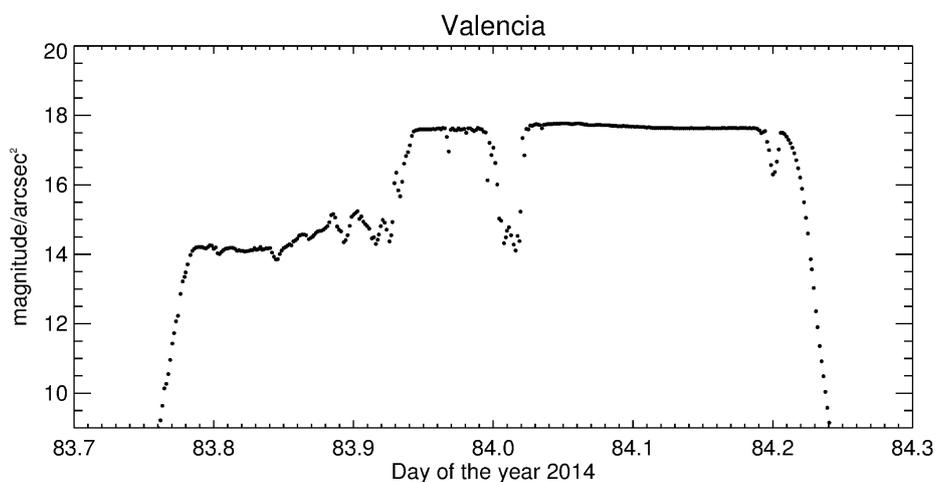


Figure 1: Passage of a cloud system above Valencia on the night of March 25th, 2014.

These initial results should be confirmed with series of longer and better data. We have to keep in mind that March was very cloudy and most festival activities coincided with full moon days.

#### 4 The Serrania region, a pristine place

The Serrania is located in northwestern direction from Valencia and can be considered one of the darkest areas of the Valencian territory as it is clearly demonstrated in previous studies by the authors of this work [5]. It is a vast territory in which there is only a permanent measuring point in the AOUV. Therefore, temporary measures were carried out at various points of interest throughout the region. In all of them, on clear, moonless days, SQM device usually reaches values of  $21.5 \text{ mag/arcsec}^2$ .

As expected, at all points studied, the lunar cycle is perfectly reflected in the collected data. The Moon passage on the sky gradually modulates the background brightness of the night sky being the difference between new and full moon around 3 magnitudes. Contrary to what happens in a sky completely polluted as is the case of Valencia, the passage of low clouds over the detector does not increase the brightness of the night sky, quite the contrary. Clouds do not reflect light as there are any or few artificial lights but they hide the natural glow of the stars and so finally the sky appears darker.

#### 5 Tavernes de la Valldigna, moderate light pollution

Tavernes de la Valldigna, a city of 18,000 inhabitants located 50 km south of Valencia, shows an moderate light pollution that allows to observe the Milky Way in exceptional moments of

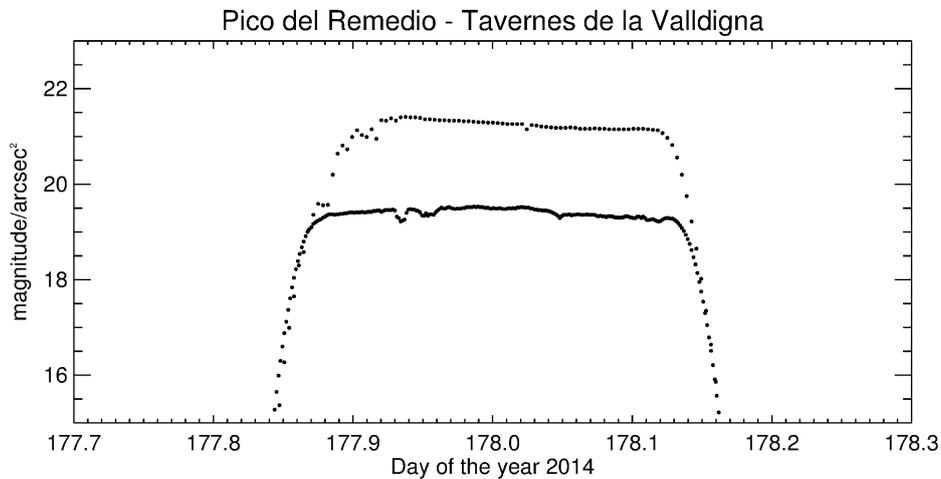


Figure 2: Comparison between Pico del Remedio and Tavernes on the moonless night of June 27th, 2014.

great darkness. There is a SQM-LU-DL device permanently located. The data reveal how the moonlight modulates the brightness of the night sky during its monthly cycle. However, as in any urban area, cloud coverage amplifies the sky glow due to the street lighting.

It is possible to estimate the human influence on the nocturnal glow comparing the data obtained on the same day in Tavernes and in the Pico del Remedio, Chelva (the Serrania region) where the sky is nearly free of light pollution. The difference between both places in a moonless night is around 2 magnitudes and can be seen in Fig. 2.

## 6 Cloud coverage effect in the Turia Natural Park

With automatic systems (Road Runner) on board of a vehicle we are mapping the night sky brightness around Valencia since three years ago. We usually follow the routes in moonless and cloudless nights. However, the sky luminance of some of these routes has also been measured on overcast nights near the Turia Natural Park. The differences between cloudy and clear night sky can be up to 2.5 magnitudes halfway between populations. This is an important fact that must be taken into account in order to study the effect on nocturnal wildlife.

## 7 Conclusions

Light pollution studies have traditionally been done on clear nights, both from satellites or from the ground. However, this work clearly shows that cloud coverage should be taken into account in the increasing of the sky luminance, especially in saturated areas where the lunar

cycle is no longer observable, as is the case of Valencia and its surroundings. This certainly affects nocturnal wildlife, where the presence or absence of moonlight is important.

The impact of the clouds over the city of Valencia is so great that in overcast nights the sky brightens more than nights in full moon anywhere in the Serrania region by a factor of 39. This affects undoubtedly wildlife, especially insects, in the three nearby natural parks, especially in the Albufera.

By contrast, in the Serrania region, with no or little polluting lights, low clouds increase the darkness of the night sky as they hide the starlight. It is a really dark place that should be protected.

The accelerated installation without any technical or environmental studies of white light LED technology with a strong blue component may soon affect this region.

More data must be collected because the measurement period used in this study is still short and our analysis, therefore, are still tentative.

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