

## RESEARCH ARTICLE

### Modeling the Law of Times

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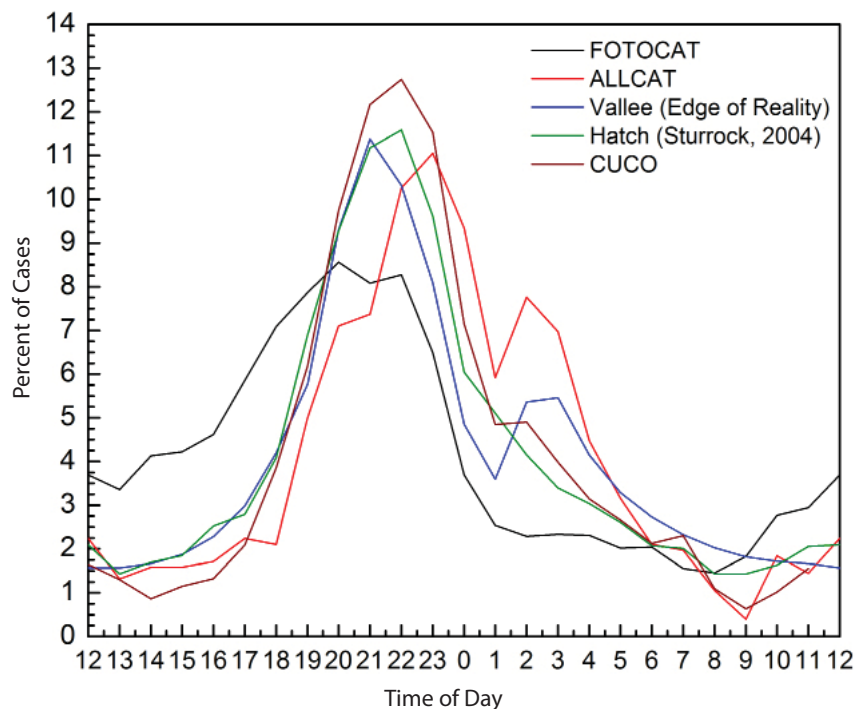
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**Abstract**—The Law of Times is a constant pattern present in every catalog of Unidentified Flying Object (UFO) sightings that describes the number of sightings occurring at a certain hour of the day. It shows that most sightings occur at night, reaching a maximum at about 21 h, and sometimes a secondary peak at about 2–3 h, whereas for daylight hours the percent of cases is low. It has long been suspected that the decrease in sightings during the night is due to social factors such as people staying indoors and thus not being able to witness UFOs. An increase in sightings occurs at earlier or later hours in the same way that the sunset time varies during the year. Taking into account these features, this paper develops a mathematical model to reproduce the Law of Times. It is based on astronomical factors such as the altitude of the Sun and the Visual Limiting Magnitude that relates to the probability of a phenomenon being visible; and a second factor related to the social habits of the population, accounting for their availability to witness the phenomenon. These two factors alone can accurately reproduce the main peak at 21–22 h of the Law of Times.

#### Introduction

Ufology can be defined as the scientific study of anomalous aerial phenomena that have been traditionally referred to as Unidentified Flying Objects (UFOs). Kenneth Arnold's sighting in 1947 (Arnold) is usually considered the cornerstone of modern UFO phenomenon. From the very beginning of ufology, the compilation of UFO cases has been an important activity for looking for patterns that can characterize and hopefully eventually explain the phenomenon. As a result, a variety of catalogs exist on which statistical analyses can be done.

One of the first patterns was found by Jacques Vallée in 1966, when analyzing the time distribution of 200 landing cases in France (Vallée 1966). The pattern shows that only a small number of sightings take place during the day, while most of them concentrate in the evening hours, reaching a maximum around 21–22 h. We will refer to the 21 h peak as the main peak. This pattern has come to be known as the Law of Times, and was soon replicated by Vicente-Juan Ballester Olmos (Ballester Olmos & Vallée 1971)



**Figure 1. Law of Times for several catalogs.**

and Ted Phillips (Swords 2010) using different catalogs, which confirmed the original discovery and led to the conclusion that a real phenomenon was taking place. Several other authors later reproduced this law (Pedersen 1978, Hynek & Vallée 1976, Gregor & Tickx 1980, Poher & Vallée 1975, Guasp 1973, Ballester Olmos & Fernández Peris 1987, Sturrock 2004, Ballester Olmos 2013, Rospars 2014), and even found evidence for it in pre-1880 UFO cases (Vallée & Aubeck 2010), which suggests that the same kind of phenomenon happened in earlier times.

Figure 1 shows several time distributions for a few catalogs. They have different scopes and geographical coverage: worldwide landing reports (VALLEE, extracted from Hynek & Vallée 1976); all kinds of reports worldwide (HATCH, extracted from Sturrock 2004); worldwide photographic records (FOTOCAT Catalog); landing reports in Spain and Portugal (ALLCAT Catalog); and all kinds of reports from Spain, Portugal, and Andorra (CUCO Catalog). They all show the same basic pattern with minor differences. Along with the main peak, in some cases a secondary

peak centered between 2 and 3 a.m. can be clearly seen. However, it seems to fade or hide, and can be only guessed at as a change in the downhill slope of the main peak in other catalogs.

By definition, a UFO is only a stimulus that could not be identified at the moment it was spotted. Whether it originated by misperception of a known object or phenomenon or is actually a phenomenon still unknown to science, is the goal of the investigation of these reports. Eventually, explanations based on known causes are found for many of these phenomena, making them Identified Flying Objects (IFOs). The question that arises then is whether there is any difference between the patterns of these two classifications. Figure 2 shows the UFO and IFO time distributions for FOTOCAT and CUCO catalogs, showing very similar patterns suggesting that both distributions are caused by similar factors if not the same factors.

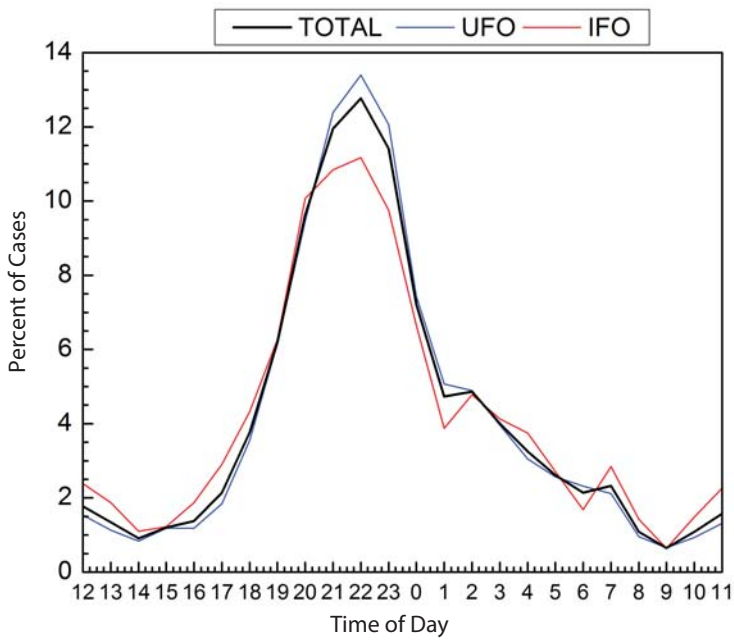
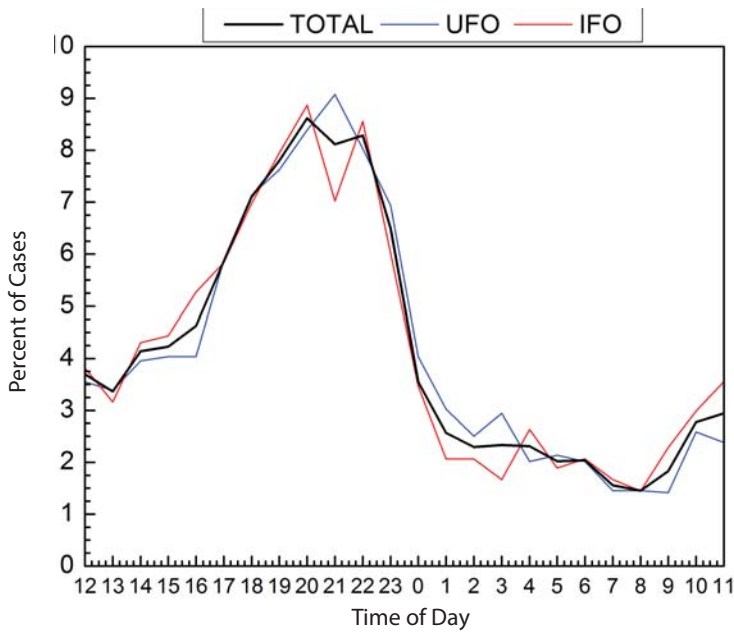
Figure 3 shows two other specific catalogs, LANIB (LANDings in the IBerean peninsula), composed of UFO cases of high strangeness (as defined in Ballester Olmos & Fernández Peris 1971), and NELIB (NEgative Landings in the IBerean peninsula), composed of IFO cases. They show basically the same main peak, but a remarkable difference in the secondary peak for IFO cases. Just recently, other authors have found statistically significant differences for UFO and IFO distributions, including differences with respect to the main peak (Rosparis 2014).

### ***Poher–Vallée Interpretation of the Law of Times***

After finding this characteristic pattern, it is only natural that interpretations were put forward to explain the nature of the graph and its relation to UFO phenomena. Perhaps the most widespread interpretation is that of Poher and Vallée, after the analysis of a database of close encounters (Poher & Vallée 1975). Their assumption was that these encounters occurred mostly at night, and the decrease of reports after the maximum was because of people staying inside at night, and not being able to witness the UFOs. That meant that there could be a significant amount of unreported landings.

This interpretation assumes that UFOs have a specific activity dependent on time that is modulated by a social factor determined by the probability of people being able to encounter UFOs. Poher and Vallée deduced that the UFO activity could be approximated to a gaussian curve, showing that the rate of potential encounters to the actual number of reports could be 14 to 1.

Thus, this interpretation takes into account two factors: a gaussian UFO activity centered at night, and a social factor determined by the time people are out of their homes and able to witness a UFO Close Encounter. This interpretation, however, does not explain the apparition of the secondary peak.



**Figure 2.** (Top) FOTOCAT (2,479 UFO cases and 2,247 IFO cases), (Bottom) CUCO (3,973 UFO cases and 1,547 IFO cases).

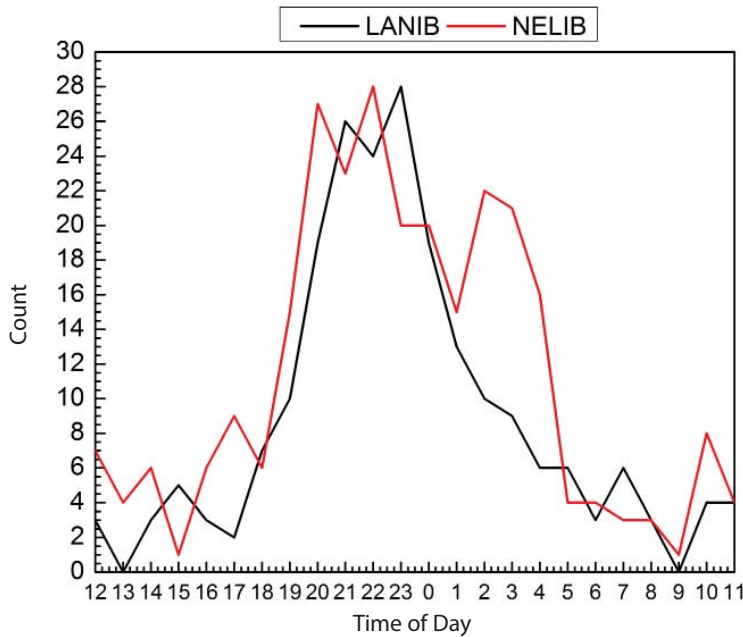


Figure 3. LANIB (213 UFO cases) and NELIB (273 IFO cases).

**Process Theory**

Another not so widespread interpretation was given by Miguel Guasp, who proposed a UFO Process Theory (Guasp 1973). This theory was developed with the intent to provide a tool to work on catalogs and extract useful data about UFOs. The initial assumption was that real objects, coming from a point in outer space like Mars or any other planet, arrived at a specific point on Earth. But, during entry into the atmosphere, their trajectory changed depending on mission-specific variables in order to reach their final destination. Applying this theory to the 1968 wave in Spain (a small catalog of 29 cases), it was found that the distribution of one of these mission-specific variables ( $|\alpha|$ ) resembled the Law of Times, and therefore, this parameter described some aspect of those objects.

Process Theory assumed that objects travelled to Earth using the shortest trajectory. Since there are more points outside Earth’s orbit than inside, objects would be more likely to arrive on Earth on the dark side, i.e. at night. UFO activity would be again a gaussian-shaped curve, centered around midnight. The apparition of the secondary peak would be caused by the mission-specific variable  $\alpha$ .

This interpretation relates UFO activity to the position of the Sun. But it does not take into account a social factor as Poher and Vallée did. However,

the math involved in this Process Theory shows a direct relationship of variable  $\alpha$  with time, and thus it is normal that  $\alpha$  distribution reflects the Law of Times. At this point, Process Theory questioned causality: Is the time distribution causing the distribution of  $\alpha$ ? Or was the Law of Times the effect of  $\alpha$  distribution? The latter implies that  $\alpha$  is a variable describing the object's behavior. But the former implies that if the time distribution can be explained in some other terms, then parameter  $\alpha$  is only another description of the same phenomenon.

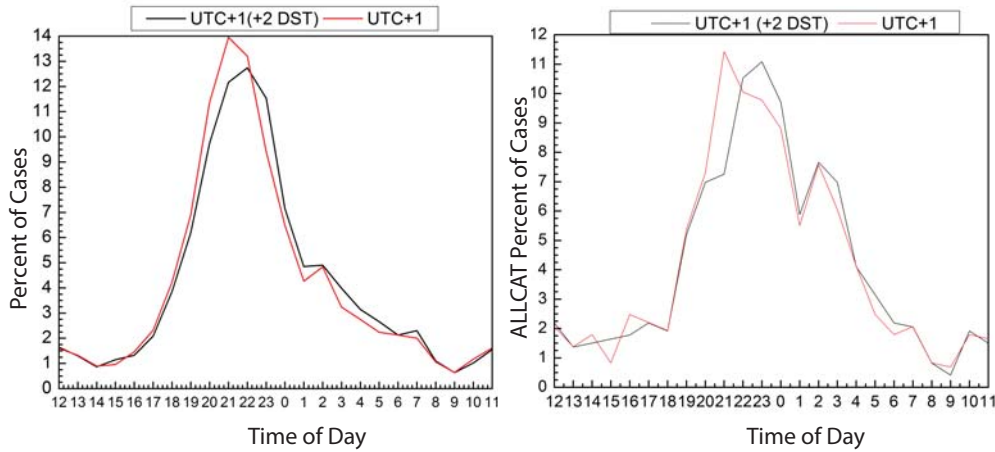
### ***Influence of the Seasons***

At least two works have analyzed the dependence of the Law of Times on the season of the year. In 1978, Per Pedersen, from the Scandinavian UFO Information center (SUFOI) (Pedersen 1978) used a catalog of 227 UFO cases in Denmark in 1975 to show that the rise of the main peak had a dependence on the season of the year. Plotting the Law of Times for winter and summer cases showed that sightings occurred earlier in winter than in summer. In winter the rise of the main peak started as early as 18 h, but in summer it was delayed to 21 h. This suggests a strong connection between sunset and the increase in UFO sightings. Some of the other features of the Law of Times could be related to social factors, such as the decrease of sightings as people go to bed. However, for the secondary peak at 3:30 a.m. there was no reasonable explanation that could be related to a social or astronomical factor, and it was thought to be solely related to UFO activity.

In 1980, Gregor and Tickx (Gregor & Tickx 1980) again showed a correlation between the main peak maximum and sunset for Belgian cases. For every month of the year, the main peak maximum always occurs later than sunset, but moves to earlier or later hours synchronously with the sunset. Among their conclusions was that UFO sightings were related to the elevation of the Sun relative to the horizon.

### ***Standard Time and Daylight Saving Time***

When calculating the time distribution of a catalog, bins are created to accumulate cases from a specific hour interval, and finally represented in a histogram. Catalogs usually register the official local time at the place of the sighting. However, in most countries official time changes for certain periods of the year. In the Northern Hemisphere, time is adjusted forward one hour from March or April to September or October or November in order to adjust human activity to daylight. In the Southern Hemisphere, the forward adjustment is from October to March. This adjustment is known as Daylight Saving Time (DST).



**Figure 4. (Left) CUCO, and (Right) ALLCAT.** Official time distribution, including DST (black) and standard time distribution (red).

However, not every country observes this adjustment, and not every country has always observed it. Moreover, in some countries, daylight savings varies across the time zones. As we just saw in the previous section, there is an important dependence on sunset in the Law of Times, and introducing a change in the official time due to social needs leads to artifacts or deviations like those shown in Figure 4. For both catalogs, we can see that the main peak maximum is shifted to a later time, and an abrupt change in the slope of the main peak rise can also be observed in one of them.

Therefore, it is important to correct the time of sightings to use only one daylight time for all of them. From here on, unless specified otherwise, the time distributions in figures will show the standard time after correcting the DST where needed.

### Modeling of the Law of Times

In the past, some efforts were made to quantify the differences between catalogs. One of these efforts tried to define a “Satisfactory Law of Times” (Ballester Olmos & Guasp 1972) as a reference pattern to compare with; this “satisfactory curve” used parameters such as the main peak maximum, minimum, secondary peak maximum, and so on. Those are parameters that describe the curve, but have no physical meaning. But the development of a mathematical model capable of describing and reproducing time distributions based on known factors should allow for understanding of what the causes behind the features are, and understanding similarities and differences between distributions can shed some light on the factors influencing UFO phenomena.

What the work of Pedersen and Gregor are showing is that an astronomical factor is responsible for the increase in sightings over the time distribution. On the other hand, a social factor such as the time people go to bed for the night seems to be the cause of the decrease of sightings during the night, as proposed originally by Poher and Vallée. This leads us to think that the Law of Times, or at least its main peak, is only a consequence of both factors that describe the sighting conditions—*when an object is visible*, and *how many people are available to see it*. In the next sections we will derive a model using simple and reasonable assumptions based on physical and social parameters, and show that it qualitative and quantitatively reproduces the most basic features of the Law of Times.

### **Addition of Catalogs**

Before starting the development of the model, it is interesting to deduce a mathematical property of catalogs that is independent of any model or distribution. We will refer to this property at some points in the next sections.

Given a catalog with a total of  $N$  reports, the Law of Times,  $P(h)$ , is constructed as the number of reports at hour  $h$ ,  $N(h)$ , divided by the total number of reports:

$$P(h) = \frac{N(h)}{N} \quad (1)$$

Given  $n$  different catalogs, each having  $N_i$  reports, and individual time distribution  $P_i(h)$ , after joining all of them in a single catalog we obtain a new catalog with a total of  $N_T = \sum N_i$  reports. The joint Law of Times of the new catalog is constructed as:

$$P(h) = \frac{N_1(h) + \dots + N_n(h)}{N_T} = \sum_{i=1}^n \frac{N_i(h)}{N_T}$$

Let us multiply and divide each term of the summation by the number of reports of the  $i$ -th catalog:

$$P(h) = \sum_{i=1}^n \frac{N_i}{N_T} \cdot \frac{N_i(h)}{N_i}$$

The second term is exactly the definition for the Law of Times of the  $i$ -th catalog,  $P_i(h)$ . Therefore, the joint Law of Times is a weighted average of the individual time distributions, and its weight is the proportional contribution to the total catalog.



$$P(h) = \sum_{i=1}^n \frac{N_i}{N_T} P_i(h) = \left(\frac{N_1}{N_T}\right) P_1(h) + \dots + \left(\frac{N_n}{N_T}\right) P_n(h) \quad (2)$$

This means that if we add two catalogs  $P_1$  and  $P_2$ , one contributing 80% of reports, and the other 20%, the total time distribution will be 80%  $P_1$ -like, and thus more similar to  $P_1$  than  $P_2$ .

### Mathematical Model

Let us start by assuming that at hour  $h$ , on day  $d$ , there are an undetermined number of events  $N_e(h, d)$  happening. These events may have any origin: lights in the sky, meteors, direct reflection of sunlight on balloons, clouds, or planes; lights from a car, satellites, space debris re-entry, the moon, stars, planets, ballistic missiles . . . even a genuine flying saucer or any unknown phenomenon can be considered an *event*. The nature of this event is not important at this stage, we just have to suppose that phenomena that emit or reflect light appear either in the sky or near ground level.

However, the brightness of the event, i.e. its magnitude, must be enough so that it is not eclipsed by atmospheric brightness. This means that there is a enough of a contrast between the event and the background to render it visible. Therefore, from the number of events  $N_e(h, d)$ , only a fraction will have enough contrast to be visible to the naked eye. Let us define the number of visible events,  $N_v(h, d)$  as:

$$N_v(h, d) = N_e(h, d) \cdot P_v(h, d)$$

$P_v(h, d)$  being the *visibility*, the probability of an event being visible at hour  $h$ , on day  $d$ .

But for an event to be witnessed, visibility is not the only condition. There has to be somebody present to see it. Thus, the number of witnessed events,  $N_w(h, d)$ , depends on a *witnessing probability*,  $P_w(h, d)$ , defined as the fraction of visible events that are actually witnessed:

$$N_w(h, d) = N_v(h, d) \cdot P_w(h, d) = N_e(h, d) \cdot P_v(h, d) \cdot P_w(h, d)$$

To construct the time distribution, we need to calculate the total number of witnessed events at hour  $h$ ,  $N_w(h)$ , adding all witnessed events at that hour,

$$N_w(h) = \sum_d N_w(h, d) = \sum_d N_e(h, d) \cdot P_v(h, d) \cdot P_w(h, d)$$

and finally divide by the total number of witnessed events, as defined in Equation 1:

$$P(h) = \frac{N_W(h)}{N_T} = \frac{N_W(h)}{\sum_h N_W(h)}$$

$$P(h) = \frac{\sum_d N_e(h,d) \cdot P_V(h,d) \cdot P_W(h,d)}{\sum_h [\sum_d N_e(h,d) \cdot P_V(h,d) \cdot P_W(h,d)]} \quad (3)$$

Equation 3 is a general expression that describes the Law of Times with three conditions: the presence of an event, its visibility, and the presence of a witness. The problem now is finding mathematical descriptions for the *event distribution* ( $N_e$ ), *visibility* ( $P_v$ ), and *witnessing probability* ( $P_w$ ).

### Event Distribution

From the three factors in Equation 3, event distribution is the one that can be related to UFO activity. It should reflect the probability of an event happening at hour  $h$  on day  $d$ . But, what should the event distribution for UFOs be? A catalog is composed of UFO reports that may have come from many different stimuli. That is why after an investigation, many UFO reports become IFO reports. Even so, UFO and IFO distributions are very similar, especially when there is a high count of reports (see Figure 2), suggesting that many still-unexplained reports may have usual causes.

IFO catalogs show us that there is a high variety of stimuli: stars, planets, the moon, balloons, satellites, etc. For each of these stimuli an *event distribution* can be defined. For a planet such as Venus, an activity defining the probability of it being up in the sky should be maximum during the day, zero at night, and something in between at sunrise or sunset. For stars such as Sirius, its event distribution should show a high probability on winter nights and a low probability during winter days, but the opposite during summer (in the northern hemisphere). Stimuli such as planes and satellites are constantly crossing the skies, and therefore a constant activity may be assumed.

But even if each stimuli alone may have a specific time (or even daily distribution), when considering all of them simultaneously it seems that on any day, at any time, any event may happen. Since UFO catalogs may be composed of any event, a simple assumption is to think that the most general event distribution is a constant probability for any day and any hour. That is,

$$N_e(h, d) = N_0$$

After substitution in Equation 3,  $N_0$  is a constant that can be extracted from the summations, and cancels out, resulting in an event-independent express

$$P(h) = \frac{\sum_d P_V(h, d) \cdot P_W(h, d)}{\sum_h [\sum_d P_V(h, d) \cdot P_W(h, d)]} \quad (4)$$

Therefore, a constant activity becomes some sort of *Null Hypothesis*, mathematically independent of the events. The assumption of a constant activity reflects the fact that UFO catalogs are composed of many different events, including potential IFO cases as well as potential genuine strange or unknown phenomena. However, as UFO cases are solved to become IFO cases, at some point if there is genuine UFO activity those cases would be the ones contributing the most to the catalog, and its own time distribution should reveal itself, as explained in the section “Addition of Catalogs.”

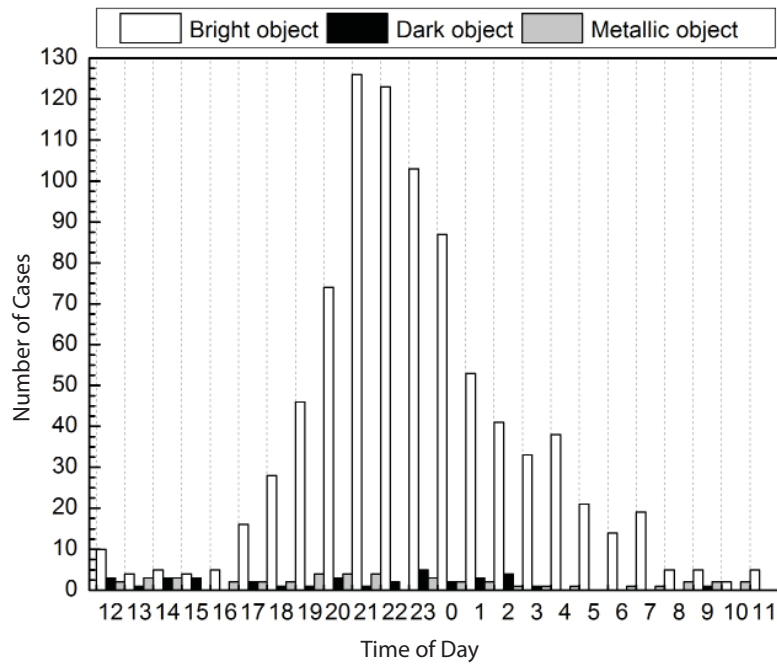
For the next sections, we will continue the development of the model under the assumption of a constant activity.

### **Visibility**

We defined visibility as the probability of an event having a contrast with respect to the background enough to be visible to the naked eye. Objects can either emit, reflect, or absorb light, and whether it is visible or not depends on the atmospheric luminosity, which is determined by the night/day cycle, geographical coordinates, and season of the year. For night time, it is easy to understand that events need a positive contrast, i.e. events must be brighter than the background. In this case, an appropriate variable to use is the visual magnitude.

On the other hand, during daytime the background is already bright, and objects can also be seen either due to a negative contrast (i.e. an object being darker than the background), or by color contrast (having a color different from the background). But how many “*non-luminous*” UFOs are usually reported? A statistical study by Poher (Poher 1976) showed that approximately 98% out of 458 cases could be classified as “*gleam,*” “*luminous,*” “*bright,*” “*brilliant,*” “*luminous with various terms,*” or “*reflects light*”; and only about 2% as “*non luminous.*” This percent increases to about 6% (out of 31 cases) for daylight hours.

Similar values can be obtained from the CUCO catalog. Up to 947 entries (including UFO and IFO) have an explicit description that allows us to classify them as:



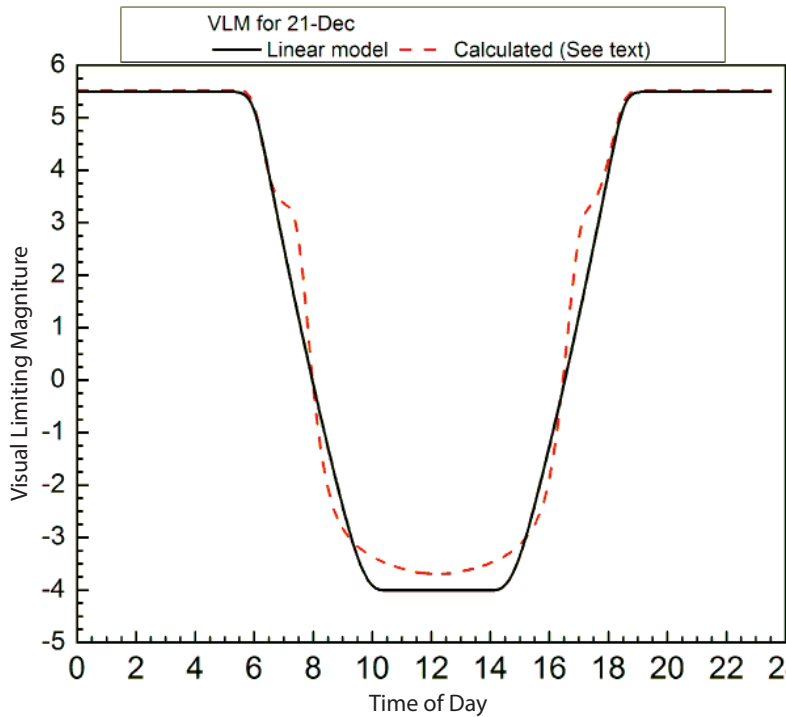
**Figure 5. Time distribution for bright and dark cases in CUCO.**

- Objects described as: luminous, bright, star-like, balls of fire, emitting or reflecting light of different colors (867)
- Objects described as: metallic, silvery, or reflective (44)
- Objects described as: non-luminous, dark, grey, black, shadow (36)

The first two can be easily grouped as bright objects creating a positive luminous contrast, and account for 96% of the total. The third one corresponds to non-luminous objects, and accounts for 4%. Regarding only daylight hours, non-luminous entries account for 9% of objects seen between 8 h and 19 h, whereas bright and metallic or reflecting objects represent 91%. But this increase in percentage is due to a decrease in the count of bright cases. The count of non-luminous UFOs is very low throughout the whole day, as can be seen in Figure 5.

We have omitted entries that might be included in “*bright*” or “*luminous*” due to context, but lack an explicit description about brightness or luminosity.

In any case, as the Law of Times shows, most events are reported at night, when visible objects are seen due to a positive luminous contrast. What we have classified as non-luminous events represent a very small



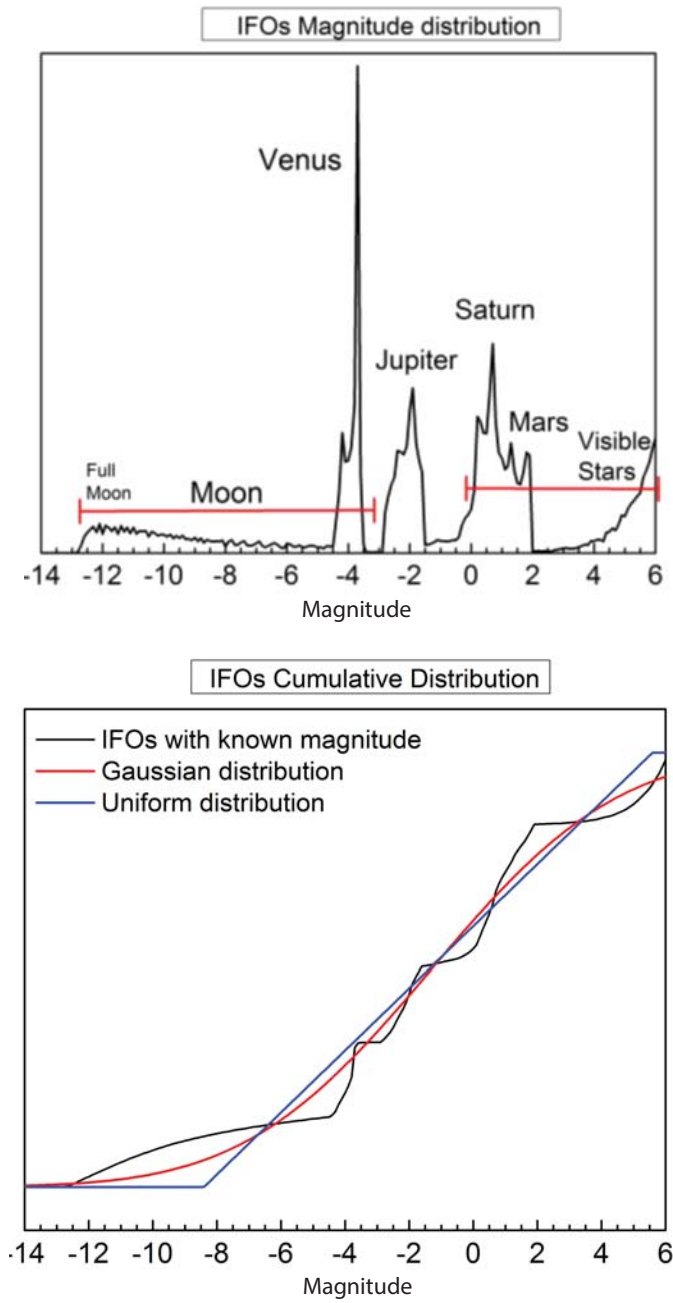
**Figure 6.** Modeled VLM for winter solstice (black line), and calculated from Vallee (1966) (dashed red line) at  $40^{\circ}$  N  $0^{\circ}$  E, UTC.

fraction of a whole UFO catalog, even for daylight hours when color contrast could be taken into account. Therefore, for our modeling, we will make the simplification of taking into account only events brighter than the background. We will use magnitude as the variable to describe the brightness of events.

Visual Limiting Magnitude (VLM) (Limiting Magnitude, [http://en.wikipedia.org/wiki/Limiting\\_magnitude](http://en.wikipedia.org/wiki/Limiting_magnitude)) is defined as the faintest magnitude that the naked eye can see. At night, this value is about 5.5. During the day, it is about  $-4$ . One must remember that the lower the magnitude, the brighter the object.

The transitions between daytime and nighttime create sunrises and sunsets, moments when the VLM will change between these two extreme values. Twilight (Twilight, <http://en.wikipedia.org/wiki/Twilight>) is the period of time when the position of the Sun changes from the horizon (altitude of  $0^{\circ}$ ) to an altitude of  $-18^{\circ}$ . Night starts when the Sun's altitude is below that value.

A simple model for the transition between daytime and night time is to



**Figure 7.** (Top) Magnitude Distribution for IFOs of known magnitude in CUCO, (Bottom) Cumulative Magnitude Distribution for IFOs of known magnitude in CUCO, and comparison with uniform and gaussian distributions.

consider that VLM changes from  $-4$  to  $5.5$  linearly with the altitude of the Sun between  $18^\circ$  and  $-18^\circ$ , and to take into account that light also vanishes while the Sun approaches the horizon during sunset (and vice versa during sunrise). Limiting Magnitude Calculations (<http://cleardarksky.com/others/BenSugerman/star.htm>) provides us with an online calculator for VLM, and we can see that our approximation is reasonable in Figure 6.

Finally, we also have to take into account that VLM depends not only on hour of the day, but also on geographical location and the day of the year.

After calculating the VLM, the next step is to assign a value for the visibility probability. Let us suppose that whenever an event appears, it has a random magnitude following a certain distribution. Since we are only looking for events brighter than the background, we can define *Visibility* as the probability of an event having a magnitude equal to or lower (brighter) than the Visual Limiting Magnitude at the time, day, and location where the event appears.

Thus, we need to know the magnitude of UFOs. This, however, presents a problem, because the perceived magnitude of an event by witnesses is a totally subjective description. On the other hand, once UFOs are identified and become IFOs, sometimes they can be related to objects with a known magnitude, or magnitude distribution. We have looked for such IFO cases in CUCO, and found the distribution shown in Figure 7. The magnitude distribution of IFOs with known magnitude is shown on Figure 7 Top. Planets show a distribution that can be approximated to a gaussian distribution. The moon, however, extends in a wider range. The distribution for the magnitude of stars was obtained from the Bright Star Catalogue (Hoffleit & Warren 1991), and can be approximated to a growing exponential.

However, these IFOs represent only 18.5% of all the IFO cases in CUCO. Many IFO cases were caused by lights of planes, reflections, satellites, spatial debris re-entry, bollides, and other stimuli for which a certain magnitude or magnitude ranges could be guessed, but not determined with certainty. For the total distribution, some basic assumptions have to be made.

Experience tells us that the multiple measurement of a single variable almost always yields a gaussian distribution around a mean value with a certain standard deviation. Such is the case of the visual magnitudes of Venus or Jupiter in Figure 7. But when several of them overlap, they form a new distribution that can cover a wider range. That is the case of Saturn and Mars' magnitudes.

What should the distribution of all possible events look like? The first approximation is to think that even if each event could show a gaussian distribution, all together would form a uniform distribution between a

maximum and minimum value. On the other hand, we can assume that, even if all possible events would cover a wide range of magnitudes, there would be a higher percentage of them around a mean value, and approximate to a gaussian distribution. We can in fact see in Figure 7 that magnitude values are centered between  $-4$  and  $2$ .

In any case, our definition of visibility implies that it is not the distribution itself but the Cumulative Distribution that we must look at (Figure 7 Bottom), to consider only objects with a magnitude greater than a given VLM for a determined day and time. Figure 7 also shows the approximations for uniform and gaussian distributions. From here on, we will assume a gaussian distribution for a magnitude of events that can be parametrized by a mean value  $\mu$  and a deviation  $\sigma$  and expressed by:

$$P_V(h, d) = \int_{-\infty}^{VLM(h, d)} \frac{1}{\sqrt{2\pi}\sigma^2} e^{-\frac{(v-\mu)^2}{2\sigma^2}} dv \approx \frac{1}{2} \left[ 1 + \operatorname{erf} \left( \frac{VLM(h, d) - \mu}{\sqrt{2}\sigma} \right) \right] \quad (5)$$

In summary,  $P_V(h, d)$  is a rather complex function that has to be calculated in several steps:

- Calculate the elevation of the Sun with respect to the horizon, depending on latitude and longitude of the location, day of the year, and standard time.
- Calculate VLM as a function of the elevation of the Sun.
- Calculate  $P_V$  as the probability of an event having a magnitude brighter than VLM.

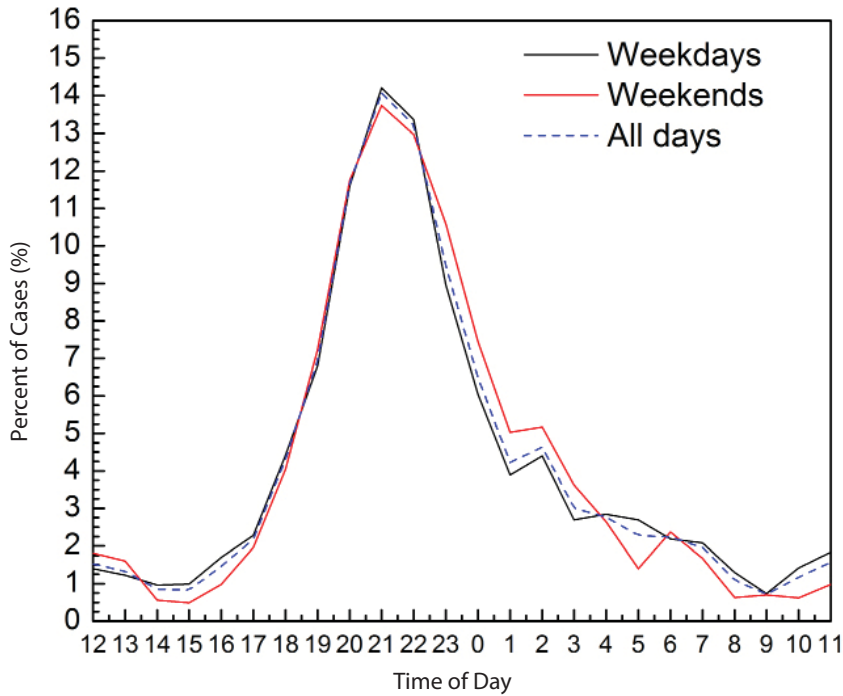
Taking into account the annual periodicity of night/day cycles helps to simplify and accelerate calculations, as the summation can be done over the days of the period of interest. For instance, if the interest is in reproducing a catalog covering several years, the summation of days can be done only over the 365 days of a single year.

$$P(h) = \frac{\sum_{d=1}^{31-Dec} P_V(h, d) \cdot P_W(h, d)}{\sum_h \left[ \sum_{d=1}^{31-Dec} P_V(h, d) \cdot P_W(h, d) \right]} \quad (6)$$

But the summation can also be done over a single month to have a *Monthly Law of Times*:

$$P(h) = \frac{\sum_{d=1}^{31-Jul} P_V(h, d) \cdot P_W(h, d)}{\sum_h \left[ \sum_{d=1}^{31-Jul} P_V(h, d) \cdot P_W(h, d) \right]} \quad (7)$$





**Figure 8. Law of Times for weekends, weekdays, and every day.**

Other periodicities such as seasonal periods also can be considered to construct a *Winter Law of Times*, a *Summer Law of Times*, and so on. . . . The possibilities the model offers are flexible enough to analyze different situations.

### **Witnessing Probability**

This is the most difficult factor to model, since it is meant to represent a social habit. The most intuitive idea is to represent the fraction of the population that is awake as a function of time. The more people who are awake, the higher the probability that somebody can witness an event.

The easiest assumption is to consider that sleep habits are the same every day. However, we can find differences between weekdays and weekends. Figure 8 shows the time distribution for weekdays and weekends for CUCCO. The rise of the main peak starts at the same time for both, but the decrease shows a small but clear difference, which can be attributed to people going to bed later on weekends.

**TABLE 1**  
**Day of the Week Distribution for CUCO**

Day	Number of cases	Percent of cases
Monday	579	12.6 %
Tuesday	615	13.4 %
Wednesday	627	13.7 %
Thursday	649	14.1 %
Friday	688	15.0 %
Saturday	726	15.8 %
Sunday	709	15.4 %

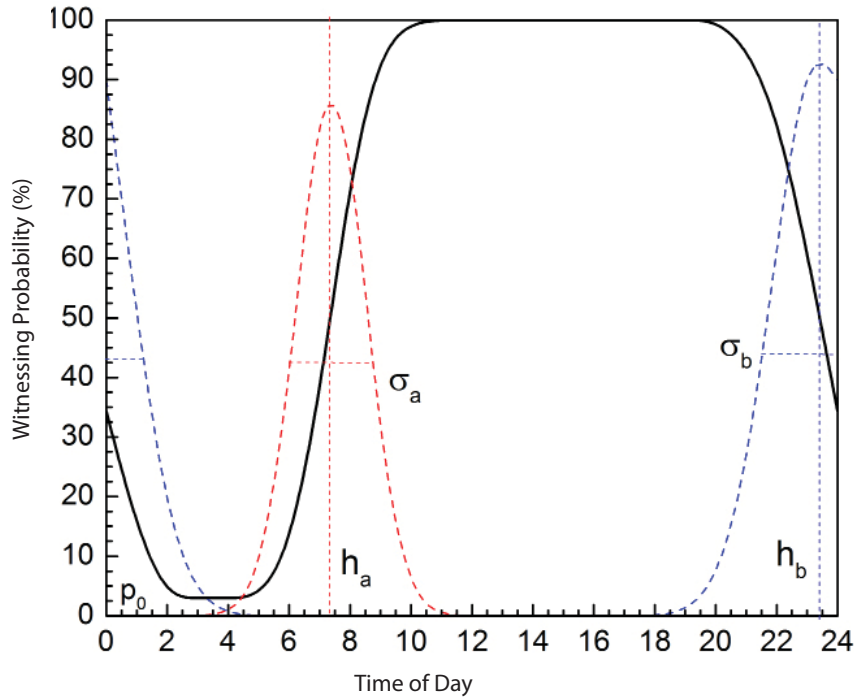
It is also interesting to note that the daily distribution shows a higher count of cases during weekends than expected for a uniform distribution ( $\chi^2 = 26.26$ ,  $p$ -value = 0.0002, see Table 1). However, the total Law of Times, when taking into account all the days, is almost a replica of the weekday time distribution. Even if during weekends UFOs are seen more than expected by chance, they only account for 31%, while 69% of cases are seen during weekdays. Thus, when taking into account all cases, the time distribution of weekdays weights more than that for weekends. As explained in the section “Addition of Catalogs,” the total distribution is a weighted average of both distributions, and so we can consider that the *Go-to-Bed* time averages accordingly.

The same argument can be applied to monthly distributions. Summer months may have people going to bed later because of longer days, and people enjoying their holidays. But we can also consider that the total time distribution is a weighted average of all the months. Therefore, we can model a constant habit throughout the year, but assuming that it will represent an average, while the actual habits can be different for each month or day of the year.

Thus, Equation 4 can be then rewritten with  $P_w$  independent of the day, and removed from the summation on  $d$ :

$$P(h) = \frac{P_W(h) \cdot \sum_d P_V(h,d)}{\sum_h [P_W(h) \cdot \sum_d P_V(h,d)]} \quad (8)$$

To model  $P_w$ , we will suppose a normal distribution for the *Wake-Up* time of the population, and another normal distribution for the *Go-to-Bed* time.



**Figure 9.** (Solid black line) Witnessing Probability, (Red/blue dashed lines) Wake-Up and Go-to-Bed distributions.

$$P_{w-u}(h) \propto e^{-\frac{(h_a-h)^2}{2\sigma_a^2}}$$

$$P_{g-b}(h) \propto e^{-\frac{(h_b-h)^2}{2\sigma_b^2}}$$

- $h_a$  : Mean Wake-Up time.
- $\sigma_a$  : Standard deviation of Wake-Up time.
- $h_b$  : Mean Go-to-Bed time.
- $\sigma_b$  : Standard deviation of Go-to-Bed time.
- $p_0$  : Minimum percentage of the population that is awake at night.

The percentage of the population that is awake can be calculated as the Cumulative Distribution of the Wake-Up distribution minus that of the Go-to-Bed distribution:

$$P_w(h) = p_0 + (1 - p_0) \cdot \left[ \int_0^h P_{w-u}(h') dh' - \int_0^h P_{g-b}(h') dh' \right]$$

$$P_w(h) \approx p_0 + (1 - p_0) \cdot \left[ \frac{1}{2} \left( 1 + \operatorname{erf} \left( \frac{h - h_a}{\sqrt{2\sigma_a^2}} \right) \right) - \frac{1}{2} \left( 1 + \operatorname{erf} \left( \frac{h - h_b}{\sqrt{2\sigma_b^2}} \right) \right) \right]$$

A minimum number of the population may remain awake at night,  $p_0$ . We can think that this value represents people working at night, or awake for any other reason. Figure 9 shows  $P_w$ , as well as the meaning of the parameters.

### Qualitative Analysis of the Model

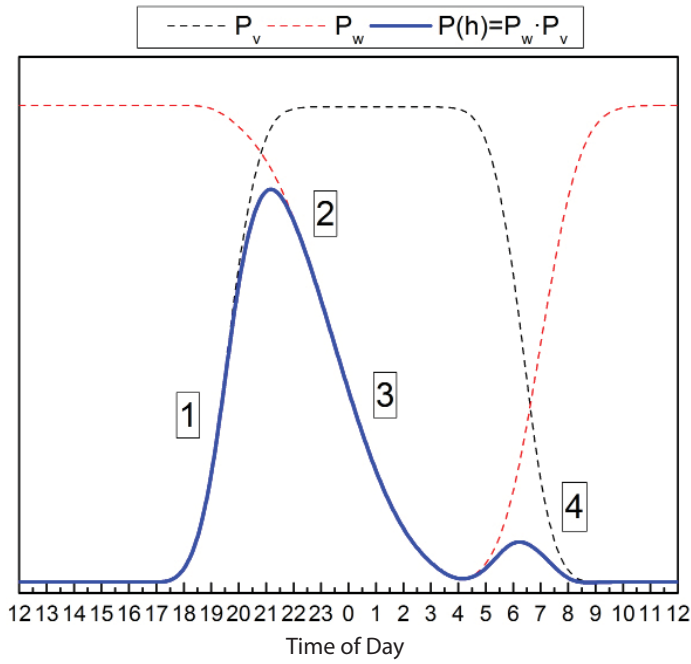
Once  $P_w(h)$  and  $P_v(h,d)$  have been modeled, the Law of Times is related to the multiplication of both functions: A peak is formed right after sunset.

During daylight hours, most of the population is awake and there is a high probability of witnessing an event. However, the Visual Limiting Magnitude is as high as  $-4$ , meaning that only very bright events are visible. Therefore, a low percentage of cases can be reported during those hours. The opposite reasoning is valid during most of the nighttime: A VLM of 5.5 makes even faint events visible, but the fraction of people awake is low, again yielding a low percentage of reported cases.

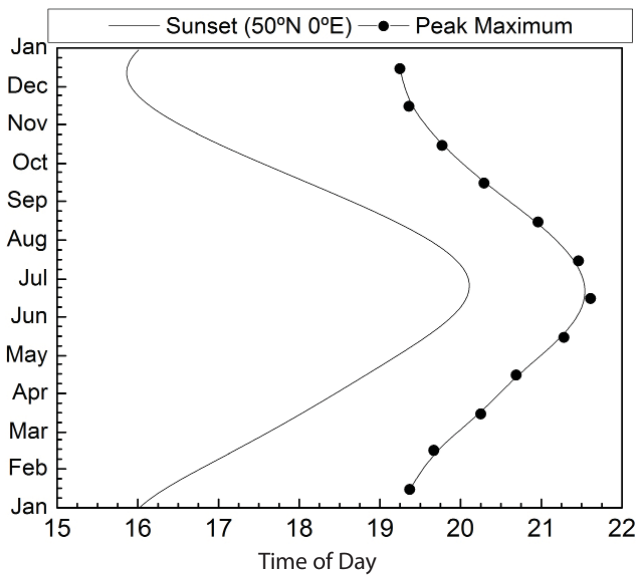
The main feature of the Law of Times is the 21–22 h peak. It is the consequence of an increase in visibility due to sunset, as well as still having a high percentage of the population awake (Figure 10-1). The combination of both factors causes the peak to reach its maximum value (Figure 10-2). Then, as people go to bed, there is a decrease in reported events (Figure 10-3).

As shown previously, the main peak moves to earlier or later hours depending on the day of the year. It is possible to reproduce this behavior with our model. Figure 11 has been produced using Equation 8, varying only the month over which the summation in  $d$  is done, while all other parameters remain unchanged. The qualitative behavior is essentially the same as that shown by Pedersen (1978) and Gregor and Tickx (1980).

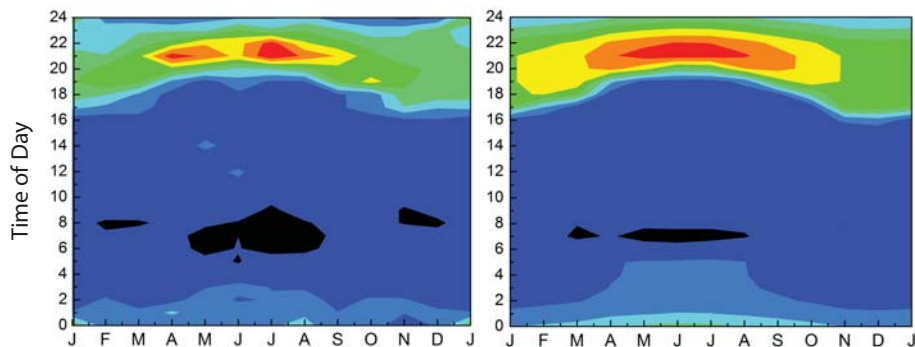
We have also analyzed a list of UFO sightings for California, taken from NUFORC (National UFO Reporting Center, <http://www.nuforc.org/>), with 9,225 cases. No particular revision was made in order to reject cases because of duplication, hoaxes, or for any other reason. The list was used as



**Figure 10. Law of Times as the multiplication of  $P_v$  and  $P_w$ .** Main features are: 1–peak rise, 2–peak maximum, 3–peak decrease, and 4–morning peak/valley.



**Figure 11. Shift of main peak position as sunset changes throughout the year.** Calculated at 50° N, 0° E (UTC).



**Figure 12. (Left) Monthly Law of Times in California (Source: NUFORC), (Right) Monthly Law of Times from Model.**

it is. There are enough entries to construct monthly histograms with about 700 cases per month (Figure 12 Left; No correction for Daylight Saving Time was done). Colors map the percentage of cases, with black and blue for the lowest values, and yellow and red for the highest values. Figure 12 Right shows a reproduction of the Monthly Law of Times using the model.

The data allows us to verify another feature: the increase in percentage of cases of the main peak during summer months. This increase in percentage is not to be confused with an increase in the absolute number of cases. It can be understood by thinking that in summertime nights are shorter. As observations are more frequent at night time, in summer they tend to be grouped in a shorter time frame before people go to bed. On the contrary, in winter, with longer nights, observations can be scattered over a longer time frame. Hence the increase in peak maximum value (in percentage) during summer months.

The model indicates that a fourth feature could exist in time distributions, which should appear at the moment when  $P_w$  and  $P_v$  cross again at sunrise (Figure 10-4). The model predicts either a small peak or a valley:

- If people wake up when it is still dark, the percentage of cases should increase, creating a *morning peak*. This situation would be typical of winter.
- If sunrise starts before a significant number of people wakes up, a small *morning valley* would be observed. This situation could happen in summer.

This last feature could be difficult to reproduce in the model, since it is near the daylight baseline, although in Figure 12 there seems to be a small morning valley during summer.

## Application to Catalogs

### CUCO

CUCO (CUCO Catalog) compiles all kinds of UFO sightings in Spain, Portugal, and Andorra. It contains 5,220 entries (including UFOs and IFOs) in which the hour of the sighting is registered. For a direct comparison of the model and the Law of Times for CUCO, it is necessary to assign values to all the parameters that we have seen during the development of the model. These parameters are a priori unknown to us. However, we will see that some of them can be fixed, and for others an approximate value can be guessed. After that, a fit of the model to the time distribution can be done, and then we can analyze whether the final value of the parameters is reasonable or not.

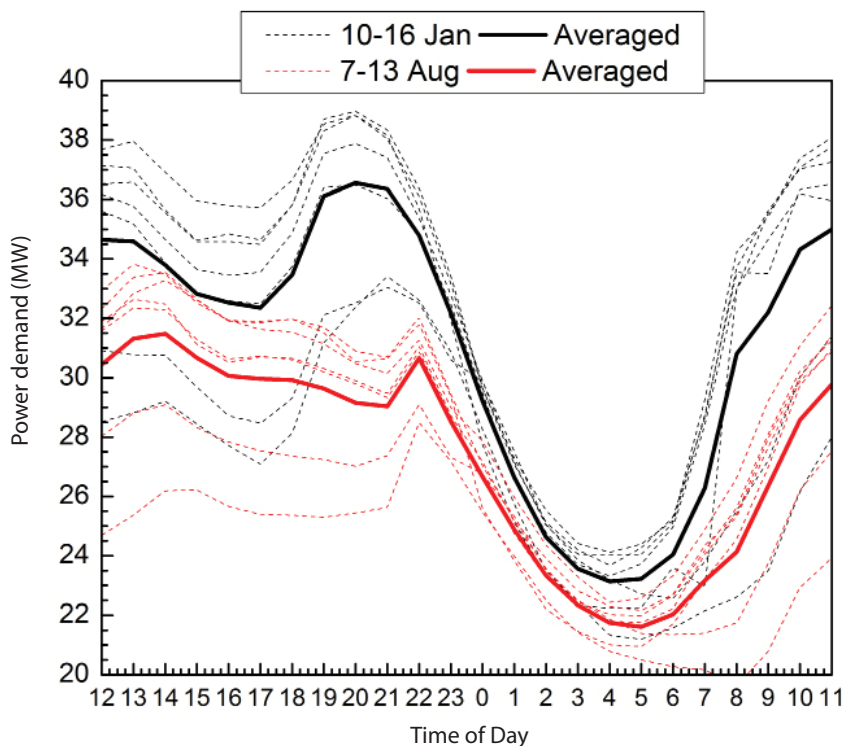
**Witnessing Probability parameters.** We modeled a social factor accounting for the availability of people witnessing a visible event as a proportion of people awake. In 1975, Poher and Vallée used French statistics about working populations not at home for a similar purpose. Another way of having an estimate of human activity is looking at the electrical demand for the country. The electrical demand is low during the night when most people are sleeping. It rises in the morning as people wake up and get ready for work, and as industries begin demanding energy. The demand remains high throughout the day until people go to bed again.

Figure 13 shows the electrical demand in Spain for two different weeks in winter and summer. Despite the difference in the absolute value of the demand for power, the shape of both curves is quite similar. We can use this curve as a first approximation to Witnessing Probability. The parameters for  $P_w(h)$  that best correlate with power demand are shown in Table 2.

**TABLE 2**

**Parameters for  $P_w$  That Maximizes Correlation with Energy Demand (Figure 13)**

Parameter	Value
Wake-Up time ( $h_a$ )	7:23 h
Wake-Up deviation ( $\sigma_a$ )	0.99 h
Go-to-Bed time ( $h_b$ )	0:03 h
Go-to-Bed deviation ( $\sigma_b$ )	1.39 h
Awake population at night ( $p_0$ )	3 %
Correlation coefficient	0.97



**Figure 13. Averaged electrical demand in two weeks of 2013 (Red Eléctrica Española).**

**Geographical coordinates and time zones.** Geographical parameters for the model are latitude ( $\phi$ ) and longitude ( $\lambda$ ) of the location of the sighting. These parameters, along with the local time and time zone, are used to determine the altitude of the Sun, and thus some dependence of the time distribution on them is expected, especially regarding  $\lambda$ : Given two different locations with the same local time, sunset occurs later in the one to the west, and hence, the main peak rises later than in the other location to the east.

This effect can be seen in CUCO. We have constructed the Law of Times for two different regions: eastern Spain (728 cases) and western Spain (1,134 cases). Figure 14 shows these two regions and their respective Law of Times; a time delay can be seen for the western region, as predicted.

In any catalog, or subcatalog, sightings do not happen at a single geographical point but in several different places, creating a geographical distribution. For our western and eastern distributions, the latitude range is about the same in both regions, from  $37^\circ$  to  $43^\circ$  N. But in longitude, the eastern region covers a range from  $1.6^\circ$  E to  $2.3^\circ$  W, whereas the western ranges from  $3.7^\circ$  to  $7.4^\circ$  W. For such distributions, mean values and variances



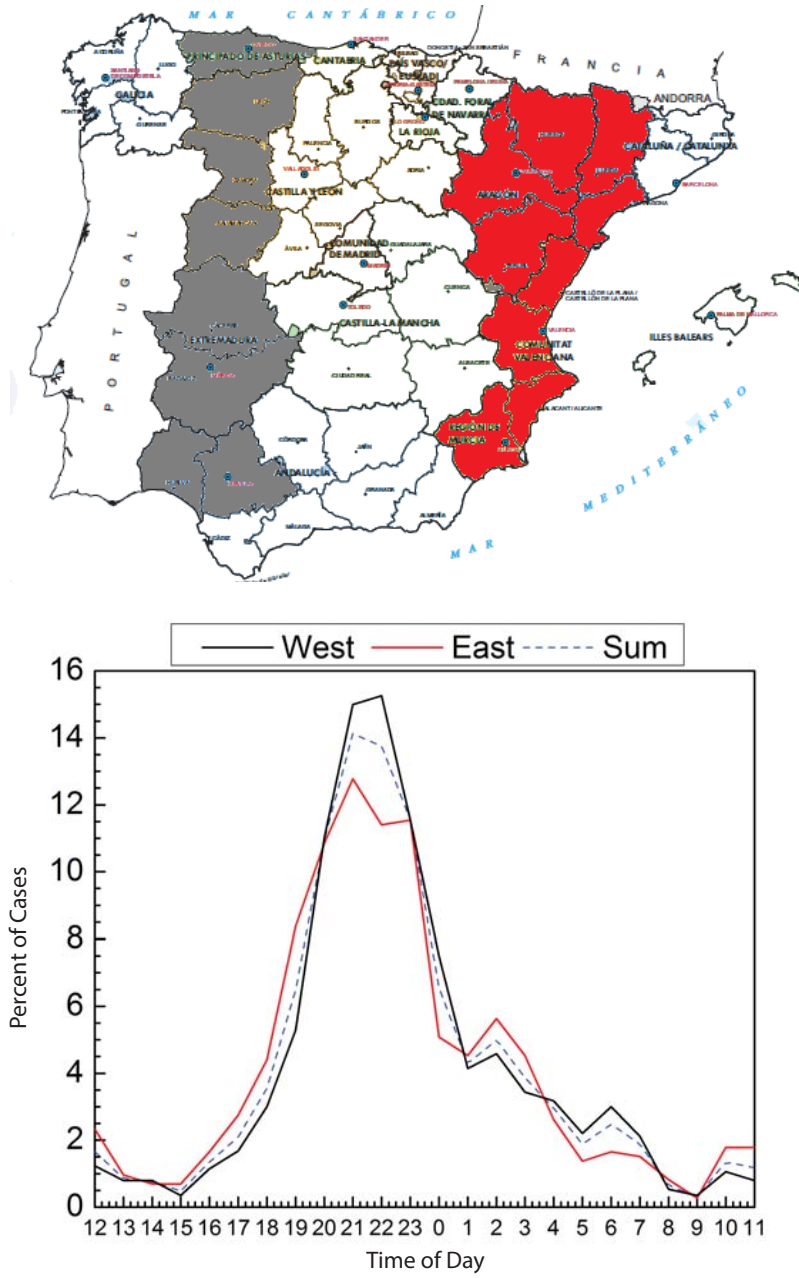


Figure 14. (Top) Selected east and west regions of Spain, (Bottom) Time distributions for east and west regions of Spain in CUCO.

can be defined:  $\lambda_{East} = 0.4^\circ \pm 0.8$  W for the eastern zone, and  $\lambda_{West} = 6.1^\circ \pm 0.5$  W for the western zone. They both cover less than  $4^\circ$ , and most of the values concentrate in a range of  $1^\circ$ .

If we join both eastern and western distributions into a single one, we will obtain a total time distribution that averages both distributions with their correspondent weight factors; and we obtain a time distribution that is centered on a mean longitude of:

$$\lambda_{Mean} = \frac{278}{278 + 1134} \lambda_{East} + \frac{1134}{278 + 1134} \lambda_{West}$$

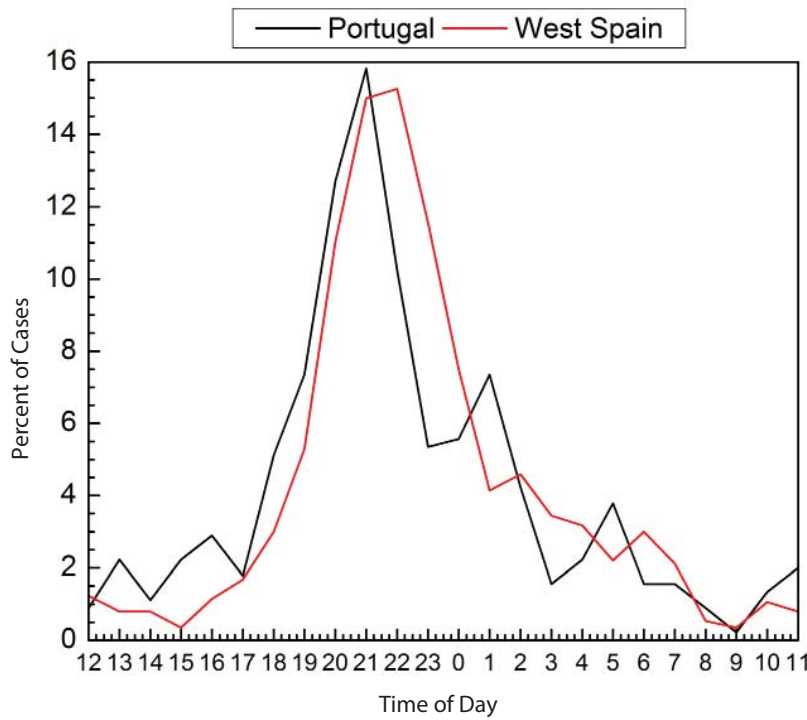
$$\lambda_{Mean} = 4.9^\circ W$$

That means that for a catalog of a wide country like Spain, we can set the geographical coordinates to fixed values representing the average latitude and longitude of the sighting locations.

However, an issue arises when we have to consider regions using different time zones. If we compare the west of Spain distribution, and the Portuguese distribution (452 cases), we can see that the main peak for Portugal seems to rise earlier than the peak for western Spain; that is Portugal seems to be to the east of western Spain (Figure 15).

Time zones exist to adjust the local time to daylight. Earth rotates at an angular speed of  $15^\circ/h$ . That means that in two places  $15^\circ$  apart in longitude, the relative position of the Sun will be the same with a difference of one hour. For western places, the Sun sets later, as we saw in our recent example of western and eastern distributions. For that reason, local time is adjusted adding or subtracting hours depending on the geographical location, creating time zones. Coordinated Universal Time (UTC) is the time reference, taken at  $0^\circ$  longitude.

Ideally, each time zone should cover  $15^\circ$ . UTC time zone spans from  $7.5^\circ$  W to  $7.5^\circ$  E; UTC + 1 spans from  $7.5^\circ$  E to  $22.5^\circ$  E, and so on. However, countries may use a time zone because of other factors (political or economic, for instance). For this reason, part of western Europe is included in the CET time zone (Central European Time, UTC + 1), when, because of their longitude, we should use the WET (Western European Time, UTC) time zone. Such is the case of France and Spain, while Portugal, and Great Britain, being at about the same longitudes, observe the WET time zone. Furthermore, some countries use more than one time zone. Canary Islands (Spain) observe WET time, while Madeira and Azores (Portugal) are in UTC-1 and UTC-2 time zones. The United States is divided into 5 different time zones and Russia uses up to 7 time zones.



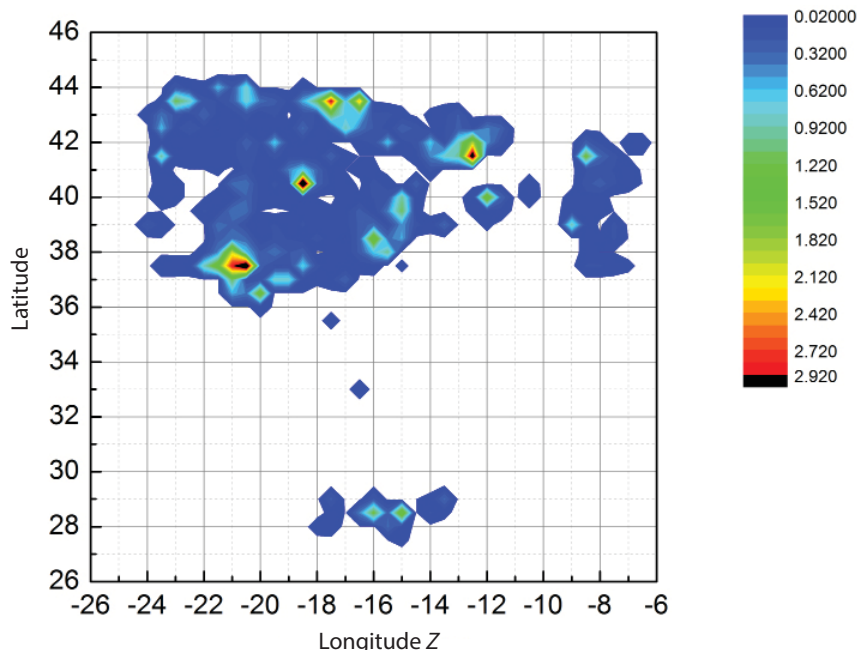
**Figure 15. Time distribution of Portugal and western Spain as defined in Figure 14.**

On the other hand, two places in about the same geographical location (like western Spain and Portugal), but with an hour of difference, means that even if the Sun sets in the same UTC time, local times are different. If we did not take into account the time zone, it would look as if the Sun had set earlier in one place than the other, as if it was to the east. Therefore, if we consider Portugal and Spain being in the same time zone, we have to correct Portugal’s longitude 15° to the east and assume their local time belongs to the CET time zone, or, conversely, correct Spain’s longitude 15° to the west, and consider its local time as observing a WET time zone. After that, we can calculate the  $\lambda$  distribution and its average value to introduce it in the model.

For the generalization of this correction, we can define a *Longitude Z*, ( $\lambda_z$ ), as the longitude at which local time can be considered with no UTC offset. It can be calculated as:

$$\lambda_z = \lambda - 15 \cdot \Delta_{UTC}$$

where  $\lambda$  and  $\Delta_{UTC}$  are the real longitude and UTC offset of the place of sighting.



**Figure 16.**  $\lambda_z$  distribution of CUCO, including Spain, Portugal, Andorra, Canary Islands, Madeira, and Azores. Color maps the percentage of cases.

If we apply this transformation to CUCO, we obtain the distribution in Figure 16. We can see that Portugal appears to the east of Spain. But we can also see that Canary Islands do not suffer any change, since they are already using a UTC + 0 time zone, and appear in their real position in the same longitude ranges than *moved* Spain. The average coordinates for the geographical distribution of CUCO are  $\phi = 40.35^\circ$  N, and  $\lambda_z = 17.98^\circ$  W, considering a UTC time zone for all the locations in the catalog: Iberian peninsula, Ceuta, Melilla, Andorra, Canary Islands, Madeira, and Azores.

Some countries have a UTC offset that makes local time synchronized with their natural solar time. That means that a longitude translation to the UTC time zone will yield values between  $7.5^\circ$  E and  $7.5^\circ$  W. For those one hour ahead of their solar times, like Spain,  $\lambda_z$  will be between  $22.5^\circ$  and  $7.5^\circ$  W. Finally, the behavior of any catalog (local, regional, or worldwide) will be as though the world has been compressed into a region from  $22.5^\circ$  W to  $7.5^\circ$  E and can be described in terms of this *Longitude Z*.

**CUCO time distribution.** Figure 17 shows CUCO and the result of the model. The model fits the main peak very well, using the same parameters that were estimated and calculated in the previous sections. Only those for

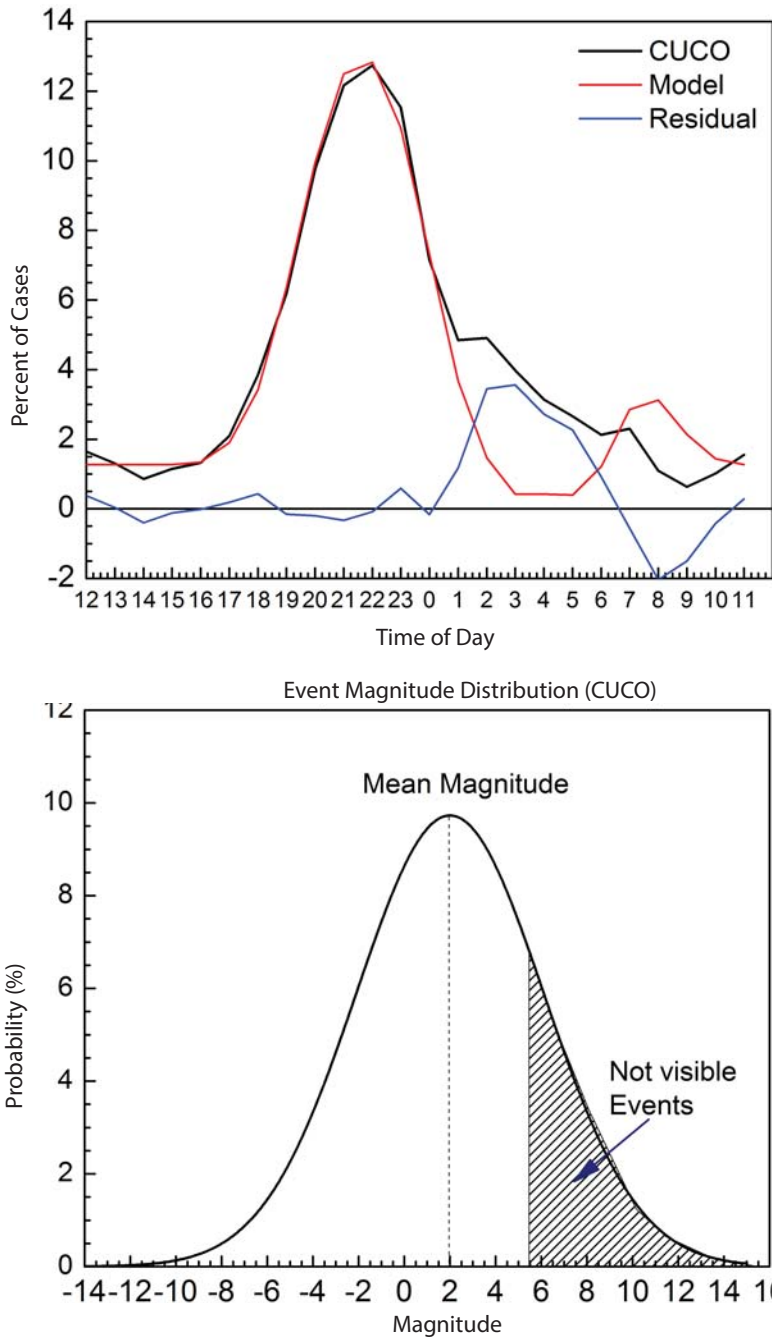


Figure 17. (Top) Law of Times for CUCO, and result of the modeling, (Bottom) Distribution of Event Magnitude for CUCO.

the magnitude of events (mean magnitude and standard deviation of events) were free to vary to fit the model.

On the other hand, cases near sunrise and morning hours are overestimated—at least for this catalog. The expected morning peak simply vanishes in the data, and the only way to reproduce it would be increasing the Wake-Up time to later hours, to values that would make no sense. This means that this parameter is not a good descriptor for the sunrise and morning features, and changes need to be made to Witnessing Probability, or a new factor needs to be introduced into the model.

The secondary peak is not reproduced either. The residuals show that it represents about 13% of cases in CUCO.

The only parameters that were varied for fitting the model were the mean magnitude of events, and its standard deviation. As the model does not reproduce all the features of the data, only the main peak was used to optimize the parameters (from 12:00 p.m. to 01:00 a.m.), yielding a coefficient of determination of  $R^2 = 0.99$ .

### ***The Influence of Technology: FOTOCAT***

The other catalog we worked with is FOTOCAT (FOTOCAT Catalog). It is a catalog composed of photographs and video footage, which means there is an important technological factor in this catalog, which we can see by looking at the time distributions shown in Figure 1.

We worked with a set of 2,247 IFO cases. These were originally classified into 7 categories:

- Hoax: fakes and manufactured flying saucers.
- Camera and film-related: development flaws, lens flares, artifacts related to the camera . . .
- Aerspatial: aircraft, condensation trails, balloons, helicopters, satellites, reentries, airborne debris . . .
- Meteorological and geophysical: clouds, mirages, ball lightning . . .
- Astronomical: bolides, stars, planets . . .
- Biological: bugs, birds, persons . . .
- Miscellaneous: automobiles, debris, ground lights . . .

We can see from this classification that some of the explanations are solely dependent on technology: development flaws, lens flares, flying-by birds or bugs, blurred objects . . . . They do not depend on visibility and are only seen after taking the image (i.e. they were not seen initially by the photographer, and hence not photographed on purpose). On the other hand, we have cases that are basically in the scope of our model: planes, satellites,

distant lights, clouds . . . . Those are events likely to have been seen by the photographer, and so photographed on purpose. The main contributions to IFO cases are Aerspatial (~33%), followed by hoaxes (~22%) and technology-related explanations (~13%).

But, we can define a broader classification of IFOs as follows:

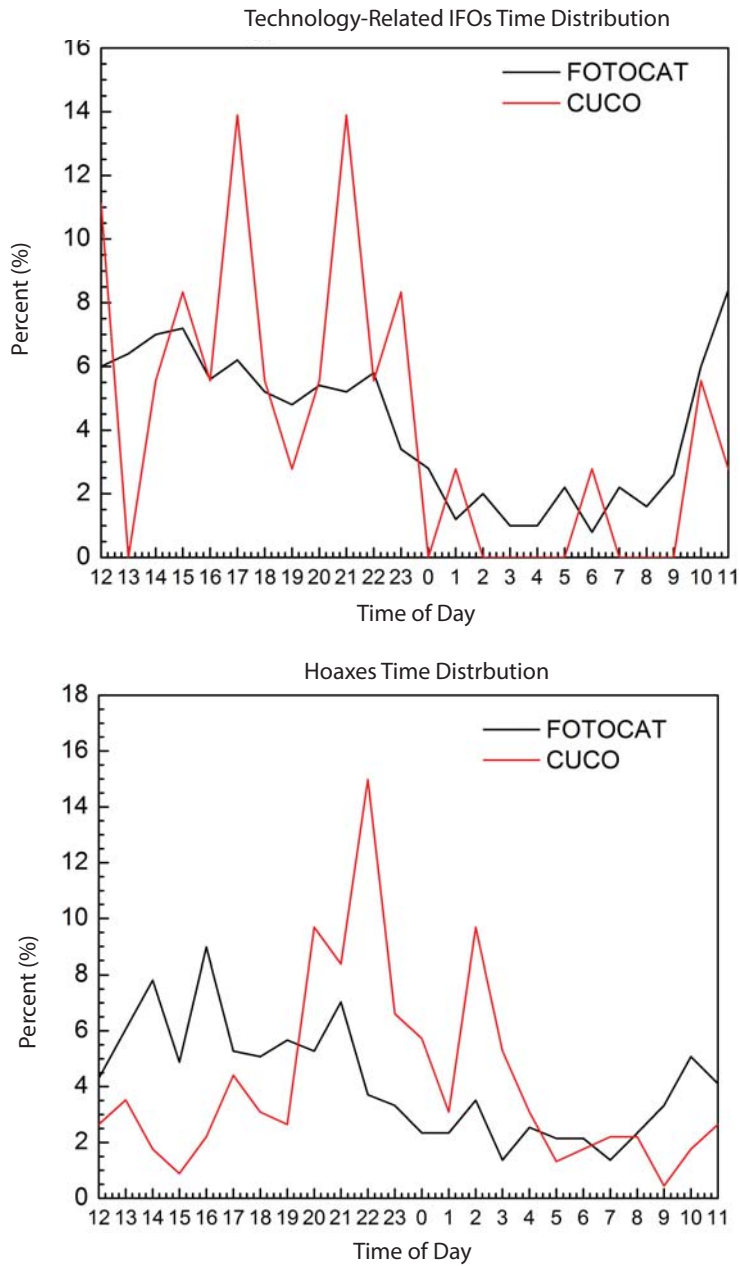
- Hoax: This is the same category as the previous Hoax category (512 cases, 25.4%).
- Accidental image: Composed of the previous categories 2 and 6 (camera and film-related; and biological). This category joins cases of UFOs most likely not seen at the moment of taking the images: film flaws, flares, flying-by birds or bugs . . . . These cases are not covered by the model developed in this work (500 cases, 24.8%).
- On-purpose image: Composed of the previous categories 3 (Aerspatial), 4 (Meteorological and Geophysical), and 5 (Astronomical). This category joins events that were likely to be seen, and hence photographed on purpose. They also are cases covered by the model developed in this work (1,005 cases, 49.8%).

Most cases from category 7 (Miscellaneous) have been reclassified into *Accidental* and *On-Purpose* new categories. Duplicated cases also have been removed, for a total of 2,017 unique IFO cases.

Let us look at the individual time distributions of each of these categories. Figure 18 shows the Law of Times for Accidental Images and Hoaxes. As expected, they do not follow the usual time distribution. It is interesting to compare the equivalent categories of IFO cases in CUCO. Technology-related IFOs (only 36 cases in CUCO) seem to follow a distribution similar to FOTOCAT. The very low count of cases produces high peaks that should be considered noise. But for hoaxes (227 cases in CUCO), the distributions are different, CUCO's resembling the usual Law of Times.

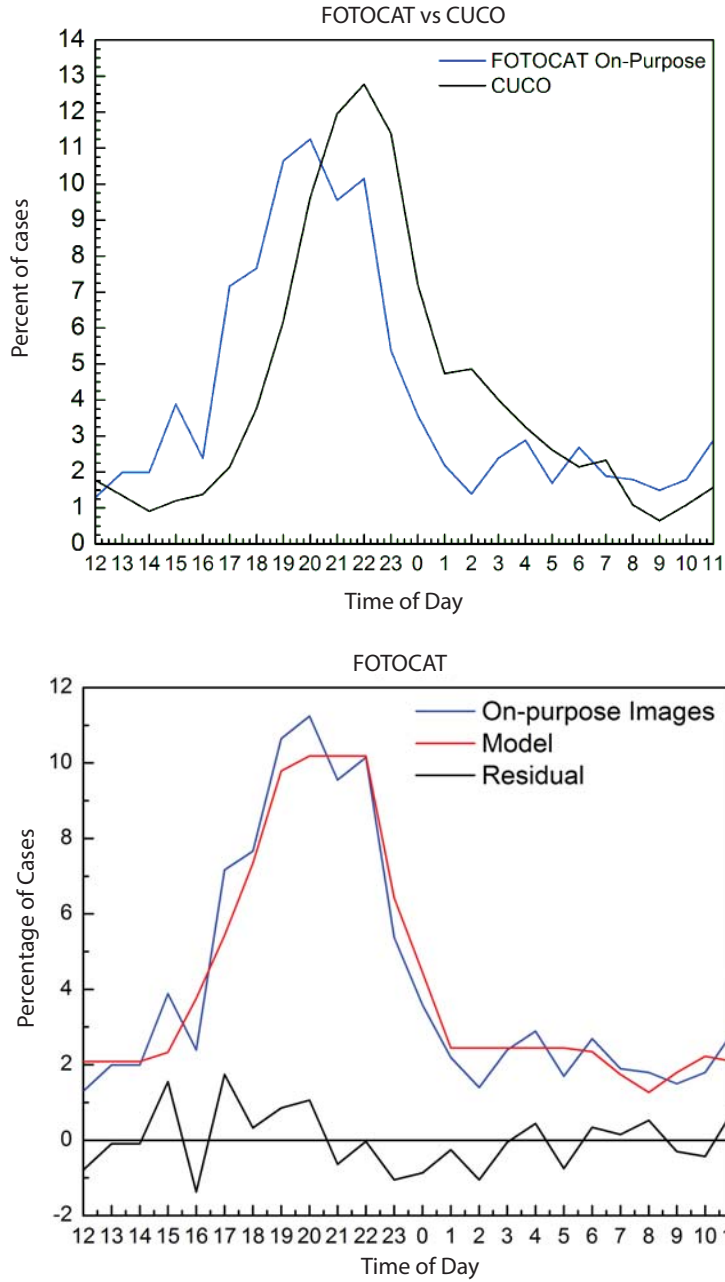
Technology-related IFOs in CUCO and Accidental Images in FOTOCAT confirm that the use of technology introduces a factor different from those used in this work. The probability of having flares when making a photograph, development flaws, blurred objects, or bugs, etc. . . . should be directly related to the number of images taken. More photographs means more opportunities to have a flaw or an artifact. It is obvious that more photographs are taken during daylight than during the night because of available light, but also because more people are awake—this time both factors are synchronized.

On the other hand, Hoax time distributions show that technology influences the way hoaxes and fakes are made. If we think of how in



**Figure 18. (Top) Law of Times for each IFO category, (Bottom) Comparison between total IFO cases, On-Purpose cases, and CUCO.**





**Figure 19. (Top) FOTOCAT On-Purpose Images and CUCO Law of Times, (Bottom) Reproduction of FOTOCAT On-Purpose images with the model.**

**TABLE 3**  
**Parameters for  $P_w$  That Maximizes Correlation of**  
**Accidental Images and Witnessing Probability**

Parameter	Value
Wake-Up time ( $h_a$ )	9:08 h
Wake-Up deviation ( $\sigma_a$ )	0.35 h
Go-to-Bed time ( $h_b$ )	23:03 h
Go-to-Bed deviation ( $\sigma_b$ )	1.47 h
Awake population at night ( $p_a$ )	24%
Correlation coefficient	0.94

FOTOCAT someone would create a fake image, it is reasonable to think that one would make a photograph or video clearly showing a fake object, and clear images are easily taken during daylight. On the other hand, in CUCO, if one wants to fool others, a stimulus has to be confused, not identified by observers, and this is more easily done at night time.

Our main focus, however, is images taken On-Purpose. This implies that the photographer saw an event and tried to take a picture of it. The origin of the sighting fits directly under the assumptions of the model, and we can see how that curve resembles the usual shape than the other categories, when compared to CUCO in Figure 19 Top. The slope of the rise of the main peak is more similar to CUCO, but it is remarkable to see that the secondary peak in the FOTOCAT On-Purpose Images distribution seems to be absent.

We can try to fix some parameters in a similar way as we did with CUCO. A close look at the three IFO categories reveals that the decrease of cases in FOTOCAT at night is at about the same time, clearly showing when people go to bed. We can take advantage of the apparent direct relationship between accidental images and human activity, and deduce starting values for Witnessing Probability. The best correlation between  $P_w$  and Accidental Images is shown in Table 3, and is as high as 0.94.

To fix the geographical parameters, a geographical distribution analysis shows that the mean position is at  $\phi = 42.58^\circ$  N,  $\lambda_z = 7.31^\circ$  W. That is  $10.7^\circ$  to the east of CUCO, which explains the fact that the FOTOCAT main peak rises earlier.

The only parameters free to be fitted into the model are those related to

**TABLE 4**  
**Model Parameters for CUCO and FOTOCAT**

Parameters		CUCO	FOTOCAT
<b>Fixed</b>	Witnessing probability ( $P_w$ )		
	Wake-Up time	7:23 h	9:08
	Wake-Up deviation	0.99	0.35
	Go-to-Bed time	0:03	23:03
	Go-to-Bed deviation	1.39	1.47
	Awake population at night	3%	24%
Visibility ( $P_v$ )	Mean latitude	40.35° N	42.58° N
	Mean longitude Z	17.98° W	7.31° W
<b>Free</b>	Mean event magnitude	2	-2.98
	Event magnitude deviation	4.1	1.26

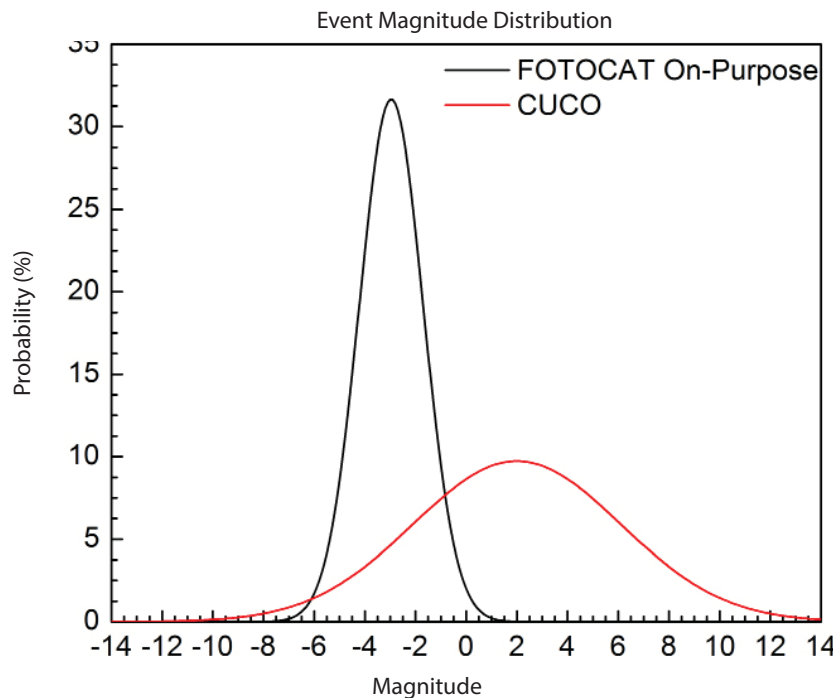
the magnitude of events. The final fit yields a Coefficient of Determination  $R^2 = 0.94$ .

### Discussion

Table 4 shows the model parameters for both CUCO and FOTOCAT. The next question to answer is whether those values are reasonable, taking into account what they represent.

For CUCO, we used the power demand to fix the parameters for Witnessing Probability. Thus, values are directly related to human activity. Results have to be interpreted as people going to bed at midnight as the mean hour, and 95% of people doing it between 21:15 and 2:45. This seems reasonable for a country like Spain. FOTOCAT, on the other hand, yields a mean Go-to-Bed time an hour earlier, and the time interval in which most of the population goes to bed is roughly the same as CUCO. These values for both catalogs seem reasonable at first sight, but should be validated with some related statistics, or social studies.

As for the Wake-Up time, we fixed a mean Wake-Up time of 7:23 h. This hour is typical for the beginning of commuter rush hours, and thus it seems reasonable. However, the number of cases is overestimated by the model. Should another factor be taken into account? In the morning people



**Figure 20. Event Magnitude distribution for CUCO and FOTOCAT.**

are just beginning their day, and going to work. Rush hour requires attention to the traffic, and some people sleep while going to work on the bus or train. In the evenings, people tend to be more relaxed, and perhaps their attention can be more easily diverted to look at the sky. Should something like an “attention factor” be included in the model?

Something similar happens in FOTOCAT. Assuming that the time distribution of accidental images is directly related to the Witnessing Probability, we fixed a Wake-Up mean time at 9:08. It is obviously a very late hour. In any case, since the catalog is strongly influenced by technology, perhaps Witnessing Probability should be interpreted as the availability of cameras, or the availability of taking images. This, again, could be related to rush hours and the beginning of the day: A person driving to work would not stop to take an image.

The parameter for people awake at night is strangely high for FOTOCAT. We do not have any interpretation for this value.

Finally, the fits give an interesting difference with CUCO, since Events for FOTOCAT need to be brighter (Figure 20). Sensibility of devices is not

the same as that of the naked eye. Also, the Limiting Magnitude can be different for different cameras or devices.

### Conclusions

To the author's best knowledge, this is the first time a quantitative model has been developed to explain the Law of Times. The model can successfully reproduce the main feature of the law, which is the peak at 21–22 h.

The model was derived using three factors: event activity, a geographical–astronomical factor, and a social factor. The second one accounts for the conditions of sightings, i.e. the light conditions are determined by the position of the Sun with respect to the location of the sighting. The third one accounts for the availability of someone to see the event.

Poher and Vallée, and Process Theory, assumed an ideal UFO activity to explain the origin of the Law of Times. We account for a similar factor in Event Activity that can be modeled in different ways. Experience shows us that among unidentified cases in catalogs, there are an undetermined number of potential IFO cases with natural or common causes. When considering all possible sources of events, a constant event activity hiding a real UFO activity can be considered, and thus the Law of Times becomes independent of event activity. Therefore, only the other two factors are enough to describe most time distributions.

With this approximation, some thoughts can be derived about the nature of events within our model. An event may be anything: lights, stars, planets, reflections on balloons or clouds . . . the only way those can be reported as UFO sightings is by misperception. The model is telling us that these misperceptions are happening continuously, and their time of sighting is solely related to the aforementioned factors.

That does not rule out the sighting of any strange or unusual phenomenon, but since UFO and IFO time distributions show basically the same curve, it is just straightforward to think that the vast majority of UFO reports may also be misperception cases that are still unexplained. However, the continuous investigation of individual UFO cases to become IFO cases should, eventually, reveal the actual UFO activity, if there is any.

We also saw that other factors can influence the time distribution, such as photographic cameras or video recorders: lens flares, flying-by birds or bugs, dust, development flaws. . . . These do not depend on astronomical factors, but on a technological one. Nowadays, it is easy and quick to take photos or videos at any time. But, was it as easy to have a camera ready at any time in the 1960s, 1970s, or 1980s? Technology evolves over time. Film sensibility, development processes, and optics have improved since the times of old manual cameras. And then, digital technology made film

cameras obsolete. Could this evolution have any influence on the time distribution of image catalogs in any way?

Hoax is another factor that is not a priori dependent on astronomy or a wake/sleep cycle, although it can be considered as a sort of social factor, and we saw that that can be indirectly influenced by technology. Furthermore, we can think about how digital image editing makes it extremely easy to create hoaxes at any time, and we can often see hoax videos going viral on YouTube. In a few decades, the time distribution of future photographic catalogs might be different from FOTOCAT.

On the topic of drawbacks, we have to mention that the secondary peak is not reproduced by the model. Its origin is totally uncertain, but on the other hand it appears in both UFO and IFO time distributions. This suggests that it cannot be attributed to real UFOs or strange-phenomena activity. Also, Witnessing Probability was thought up as a quantification for awake people. It seems to yield reasonable values to describe the main peak. But there is an overestimation for morning cases in CUCO, which can only be fitted assuming a later Wake-Up time. Also for FOTOCAT, the estimation of awake people at night seems incorrect. Therefore, a better interpretation of the Witnessing Probability is needed.

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