1	Aurora Records in the Spanish Newspaper "Extremadura" for the					
2	period 1923 – 2017					
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12	Abstract: Aurora records are a valuable proxy for understanding historical solar					
13	behavior. This study explores historical records of auroras reported in the Spanish					
14	newspaper "Extremadura" from 1923 to 2017. We have found and analyzed 31 news					
15	articles, categorizing them into direct observations and general reports. The compiled					
16	news includes significant auroral events occurred in 1926, 1938, 1950, 1956, 1957, 1958,					
17	and 1991. The news reports aurorae visible not only in Extremadura, but also across Spain					
18	and other parts of the world. We have extracted information on the characteristics, places,					
19	timing, and societal impacts of auroras, in addition to providing information on these					
20	events included in previous scientific literature. This collection of auroral reports					
21	highlights historical newspapers as documentary sources for reconstructing solar activity					
22	and its effects on Earth.					

23 Keywords: Aurora; Geomagnetic storm; Solar activity; Space climate; Historical records

24 **1. Introduction**

The study of solar activity is of great importance due to its influence on our society (Pulkkinen, 2007). Solar activity can manifest from different phenomena such as, for example, sunspots, coronal mass ejections, and auroras (Usoskin, 2023). Sunspot records represent the longest dataset of direct solar observations and, for that reason, the sunspot number is the most used index to characterize long-term solar activity (Muñoz-Jaramillo and Vaquero, 2019; Arlt and Vaquero, 2020; Clette et al., 2023). 31 Auroras are valuable proxies for studying historical solar behavior as well as offering a complementary perspective to sunspot observations (Eddy, 1976; Siscoe, 1980; 32 Silverman, 1992; Silverman and Hayakawa, 2021; Yan et al., 2023). They are more 33 34 common at high latitudes, but significant geomagnetic storms can produce auroras visible at lower latitudes (Hayakawa et al. 2018, 2020; González-Esparza et al., 2024). The 35 frequency and intensity of these events are closely linked to the solar cycle (Vázquez et 36 al., 2016). Therefore, historical records of auroras provide a valuable dataset for 37 38 reconstructing solar activity over long timescales. Some examples using historical aurora 39 records to reconstruct solar activity can be found in Love (2018), Hapgood (2019), and Hayakawa et al. (2019, 2023). 40

Historical aurora observations have also been recorded in the Iberian Peninsula in 41 different documentary sources. For example, auroral displays were observed in Spain 42 during the geomagnetic storms of 1859 and 1870 (Vaquero et al., 2008). Aurora catalogs 43 44 including Iberian records have been compiled by Rico Sinobas (1855) and Aragonès and 45 Ordaz (2010). Systematics aurora records made in Lisbon and Barcelona in the 18th and 19th centuries were presented by Vaquero and Trigo (2005) and Vaquero et al. (2010). 46 An analysis of the great auroral display in 1770 was made by Carrasco et al. (2018) from 47 48 Spanish records and an analysis of the historical catalogs by Rico Sinobas was made by Vaquero et al. (2003). Also, Carrasco and Vaquero (2020) provided new descriptions 49 50 about the great aurora observed in March 1582 (Hattori et al., 2019) made by Iberian observers. In any case, we note that aurora observations are quite rare from the Iberian 51 52 Peninsula in general and from the Extremadura region in particular.

53 Valuable information on auroras and their impact on society can be found in news published in journals and newspapers (Odenwald, 2007, 2021). In this work, we recover 54 55 all the information on auroras included in the news published by the Spanish newspaper "Extremadura" from 1923 to 2017. Despite the scarcity and dispersion of data on auroras 56 in a local newspaper such as "Extremadura", which provides information from a low-57 latitude region where these phenomena are unlikely to occur, this effort is both valuable 58 59 and necessary. Research on major geomagnetic storms can utilize these records to confirm whether auroras were observed in a region as Extremadura. Furthermore, these data may 60 61 be of particular interest to social scientists seeking to examine the impact of geomagnetic storms on public opinion throughout the 20th century. 62

The outline of this work is as follows. We provide information on the documentary source, how we have searched for aurora events in those sources and a description of the data found in Section 2. We analyze and discuss the information on different historical aurorae found in the news in Section 3. Lastly, we present final remarks in Section 4.

67 2. Data and Methodology

68 2.1. Documentary source

⁶⁹ "Extremadura" is a regional Spanish newspaper based on the region of Extremadura.
⁷⁰ Founded in 1923, it is one of the oldest and most recognized media in the region. It covers
⁷¹ local, national, and international news, with a focus on events and topics of interest for
⁷² Extremadura. Currently, in addition to its print editions, "Extremadura" also publishes
⁷³ digital content. Its publications include reports, opinions, and sections dedicated to
⁷⁴ culture, sports, economy, and society.

75 2.2. Location of news of interest

76 For this study, we have collected a digital version of all the issues published by 77 "Extremadura" since its beginning in 1923. Issues published since 2014 are available on the website https://www.elperiodicoextremadura.com/hemeroteca/, whereas the previous 78 issues were provided by the staff of "Extremadura" upon request. Once the documentary 79 sources were collected in digital format (pdf format), a search using character recognition 80 81 with more than a dozen key words (of geophysical interest) for the "Extremadura" newspaper. Thanks to this systematic search for terms of geophysical interest, our team 82 83 has located, for example, a super-bolide (Vaquero et al., 2023), the fall of a meteorite 84 (Vaquero et al., 2024) or an exceptional month of electrical storms that caused 85 considerable damage (Acero et al., 2024). Regarding aurora events, we found 31 news articles including information on them. Note that there is also the expression "Luces del 86 Norte" (Northern Lights in Spanish), but its use is very limited compared to the common 87 term "aurora". Moreover, other words that have been included in our systematic search 88 are also useful to detect news about auroras as "phenomenon". 89

90 2.3. Data description

91 General newspapers as "Extremadura" do not publish news items based on regular92 nighttime observations. However, this is not a disability for drawing conclusions about

93 the attention paid to the aurora by "Extremadura". In fact, it reflects the sporadic but94 significant interest in such rare phenomena in this region.

95 There are meteorological records in Extremadura from the 19th century (Vaquero et al., 96 2022) that could potentially contain observations of auroras to compare with the data 97 offered in the newspaper. However, as far as we know, (i) nocturnal meteorological 98 observations are not common and (ii) there are no cameras that cover the entire sky to 99 record auroras systematically and regularly in Extremadura (and in early times such as 100 1923 this type of instrumentation did not exist)

101 The news articles published by "Extremadura" on aurorae can be divided into two 102 categories: direct observations and general reports and analyses. There are 12 news items 103 including specific descriptions on direct aurora observations and 19 news items with

104 general reports.

News about observations include historical events, such as the auroras seen during geomagnetic storms in 1926, 1938, 1950, 1956, 1957, 1958, and 1991. These news items describe auroras observed not only in Extremadura, but also in other cities in Spain and around the world. Some news items provide detailed descriptions of the auroras including information about the duration and impact on society. Furthermore, there is one ambiguous news article in 1952 in which it is not clear if the observed phenomenon was actually an aurora (see Section 3.8 for more details).

General reports cover scientific research and explanations on aurorae. They include 112 113 attempts to create artificial auroras by Soviet and French scientists in 1974, explanations about aurora formation by the meteorologists Mariano Medina (news from 1979) and José 114 María Lorente (news from 1955) and on the relationship between auroras and solar 115 activity by Martin Pomerantz (news from 1972) from the Bartol Research Institute 116 (USA). Moreover, six news items between 2008 and 2009 report scientific publications 117 118 on aurorae led by Professor José Manuel Vaquero from the University of Extremadura 119 highlighting the historical impact and relevance of aurorae for contemporary scientific research. Some NASA (National Aeronautics and Space Administration) missions are 120 also mentioned, such as the Themis mission and the launch of Delta 2, both in 2007, 121 aimed to study geomagnetic storms and aurorae. Three other news items in the 2010s 122 describe expeditions to Greenland, Iceland, and Norway by aurora hunters to observe and 123 124 study the phenomenon.



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Figure 1. Locations mentioned in news items published in "Extremadura" reporting aurora observations. Different markers indicate the auroras described in the articles: red dots for the 1926 storm, blue triangles for the 1938 storm, green pentagons for the 1950 storm, black square for the 1956 storm, orange thin diamond for the 1957 storm, purple diamond for the February 1958 storm, cyan "+" for the September 1958 storm, and grey stars for the 1991 storm.

132 3. News on Historical Aurora Observations in "Extremadura": Analysis and133 Discussion

134 In this section, we describe and analyze the news articles containing specific information 135 on aurorae published in "Extremadura". A summary of the descriptions can be found in Table 1. Furthermore, Figure 1 shows a map including the location mentioned in 136 137 "Extremadura" where auroras were observed. We emphasize that there is currently no series or catalogue of auroras observed from the Iberian Peninsula during the 20th 138 century, except for the data presented in this manuscript. We also provide information 139 140 from other scientific studies and documentary sources on the geomagnetic storms that caused the auroras reported in "Extremadura" to compare with the information included 141 142 in our primary source.

Table 1. Summary of the descriptions on specific aurora observations published in the
newspaper "Extremadura" for the period 1923–2017.

DATE	PLACES	DURATION	COLOR	IMPACTS
26–27 January	New York (USA)	> 9 hours	Red	Telegraph
1926	Oslo (Norway)		Yellow	Telephone
	Sweden		Green	Transmission
	Denmark		Violet	cable
	Germany			submarine
	France			
	Northern regions			
25–26 January	San Fernando	5 hours	Red	-
1938	(Spain)			
	Throughout Europe			
20 February	Barcelona (Spain)	-	Red	Fear (of a new
1950	Hervás (Spain)			war) in part of
				society
1956	Monforte de Lemos	-	Red	-
	(Spain)			
21–22 January	Seville (Spain)	20 minutes in	Red	Firefighters
1957	Huelva (Spain)	Seville		deployed in
	Ávila (Spain)			Vienna for
	Lugo (Spain)			hours
	Monforte de Lemos			
	(Spain)			
	Salamanca (Spain)			
	Vienna (Austria)			
10-11	Panama Canal	-	-	-
February 1958				
4 – 5 September	Germany	-	-	-
1958				
November 1991	Huesca Pyrenees	-	Red	Population
	Lérida			warning of
	Zaragoza			fires

145

Aurora boreal

(POR TELEFONO) Aparece en los Estados Unidos

Dicen de Nueva York que, duran-te varias horas de la noche del 27, sobre el territorio de los Estados Unidos se distinguió una brillante aurora boreal aurora boreal.

El ca'or solar y la agita-ción de la Tierra .

Vivimos en una época de agitación extraordinaria cuyos electos parecen dejarse sentir no solamente en la vida de los pueblos sino también en nuestro planeta y en el Sol, fuente de energia y al que debe in Tiesen-stados sus en-cantos y bellezas.

tancia simétrica con la anterior y al otro lado del ecuador solar hacia los veintiun grados de latitud. Es de advertir que para que una mancha solar sea visible a sim de vista precisa que su diámetro sea por lo me-nos tres veces mayor que el de la Tie-

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Figure 2. Two news articles published in the newspaper "Extremadura" on the
geomagnetic storm of January 1926. A translation on the text mentioning the aurora and
its description can be seen in Section 3.1 [Source: newspaper "Extremadura", 1926].

150 3.1. January 1926

There are two news articles related to the geomagnetic storm of January 1926 in
"Extremadura" (Figure 2). The first one was a short news item published on 29 January
1926. Its English translation is:

"Aurora borealis. It appears in the United States. Reports from New York indicate that a
brilliant aurora borealis was seen for several hours during the night of the 27th over the
United States".

The second one, published on 17 July 1926, contains a more detailed analysis of the event.The translation regarding the mention of the aurora is:

"[...] An extremely curious phenomenon took place on 26 January [1926]. On that day, 159 160 our globe was under a dynamic ocean of prodigious power, resulting in the unleashing 161 of a formidable magnetic storm which triggered telluric currents of such violence that telegraphic and telephone communications as well as transmissions by submarine cables 162 were interrupted for several hours [...] A magnificent polar aurora covered the sky not 163 only in the polar regions, but also in our latitudes. Professor Carl Störmer, who has 164 165 carried out very interesting studies on northern lights, observed that the point of irradiation of the rays reached seventy-two degrees in the Oslo sky and that they had a 166 167 length of approximately 503 kilometers, giving us an idea of the height of our atmosphere. The phenomenon began at 18:04 in the form of a yellow-greenish arc from the north and 168 169 a strong red arc from the north-west. An hour later the spectacle was truly marvelous. 170 Gradually, the arc was transformed into an immense corona which gave off dazzling rays of a very high red coloring. From one o'clock to three o'clock on the morning of the 27th, 171 intense green and violet glows were observed, which gradually disappeared until it was 172 completely gone. This splendid aurora borealis was seen in Sweden, Denmark, Germany, 173 France and other northern regions". 174

175 The first news item reports a bright aurora seen in New York for several hours on the 176 night of 27 January 1926. The second news item describes a geomagnetic storm on 26 177 January in more detail, indicating the start at 18:04 LT with auroras observed in Oslo, Sweden, Denmark, Germany, France, and other northern regions. This storm disrupted telegraph, telephone, and submarine cable transmissions for several hours. The height of the aurora in Oslo was 72°. The news item reports that this geomagnetic storm was recorded in observatories such as Meudon (France) and Ebro (Spain). It is estimated that the diameter of the sunspot group responsible for this storm was around 100000 km. It is also mentioned the relationship between sunspots, faculae, and prominences with solar cycle.

This event was also reported by other observatories, such as the Stonyhurst College Observatory, where geomagnetic measurements, without providing any description on the aurora, were carried out (Rowland, 1926). Newspapers from U.S.A., including "The New York Times" and "The Washington Post", reported similar issues to those published by "Extremadura" such as wire service and telegraph disruptions (Odenwald, 2021).

190 3.2. January 1938

There is one news article providing some information on the geomagnetic storm occurred
on 25 – 26 January 1938, known as the Fatima Storm (since it was considered one of the
Fatima Prophesies by Roman Catholics). The English translation is:

"San Fernando - The Astronomical Observatory reported yesterday that the phenomenon
observed the night before was an Aurora Borealis of varying intensity. Its presence was
recorded at 23:00 and lasted until 2:00 a.m. in, with its maximum intensity at 21:00 and
23:30. Aurora is due to a magnetic phenomenon that can be repeated several times. In
Andalusia, no other case is remembered and that was witnessed by a crowd of people
until aurora stop perceiving. In San Fernando, the magnetic instruments had been
showing alterations for several days before.

FROM THE SCANDINAVIAN COUNTRIES TO THE MEDITERRANEAN. Berlin -All
the press are commenting on the presence of the Aurora Borealis. It has been perceptible
from the Scandinavian countries to the Mediterranean. Many data have been taken at the
observatories which will require laborious and fruitful study. There is also a widespread
opinion that the phenomenon may repeat itself.

206 IN SOUTHERN ITALY. Rome - The Aurora Borealis has been perceived all over the
207 country, but with the highest intensity in the southern regions.

IN POLAND. Warsaw - The Aurora Borealis of the day before yesterday was seen here
in the form of multicolored lines on a dark red background. Later, it splits into two bands
and in the early morning it was no longer visible.

211 The Aurora Borealis was reported to have been perceptible in all European countries".

According to this news article, the aurora was visible throughout Europe, including the Spanish Navy Observatory in San Fernando. In Andalusia (Spain), the aurora started at 9 p.m. and finished at 2 a.m. with peak intensity between 11 p.m. and 11:30 p.m (Local Time). It was perceived with great intensity in the southern regions of Italy and the color of the aurora was red from Poland.

217 Anonymous (1938) noted that the aurora was remarkable for its brilliance and the wide area of visibility, seen across Europe and as far south as Gibraltar and Sicily, on the night 218 219 of 25–26 January 1938. This source also provides observations made in different places of the British Isles. For example, the Kew Observatory reported that the aurora was red, 220 221 spreading from north-northeast to west-northwest, reaching elevations of 5° to 10° above Polaris. The aurora started at 6 p.m. according to the information sent by Mr. J.M. Brierley 222 223 to the British Meteorological Office. Hayakawa et al. (2021) estimated the intensity of this geomagnetic storm in Dcx \approx -336 nT at 23:00 UT on 25 January. We note that the 224 225 Dcx index is an extended version of the Dst index at the University of Oulu (Mursula et 226 al., 2008). The maximum Kp index was 9- (https://kp.gfz-potsdam.de/en/).

Odenwald (2021) shows that some of the impacts of this storm were disruptions in all 227 228 transatlantic radio communication and delays in express trains on the Manchester to 229 Sheffield line affecting signaling apparatus. Newspapers around the world, such as "The New York Times" and "London Times", informed on this geomagnetic storm and its 230 impact on society. Spanish newspapers in that time, as "ABC", also reported this 231 historical event. We highlight that the aurora seen during this geomagnetic storm occurred 232 233 during the Spanish Civil War. Many Spanish citizens and soldiers, unaware of the 234 phenomenon, interpreted it as a presage of greater tragedies, adding to the existing atmosphere of uncertainty and fear. Recently, some Spanish newspapers, such as "El 235 País" and "El Mundo", have published news items on this historical event (Bachiller, 236 2013). 237

238 3.3. February 1950

- Two newspaper articles in "Extremadura" reported the aurora of 20 February 1950. The
 first one was published on 21 February 1950 and the second one on 9 March 1950 (Figure
 3). Their English translations are:
- "BARCELONA At 10 p.m. last night, the presence of the aurora boreal was observed,
 which aroused the curiosity of the public. It seems that the phenomenon can be explained
 by the existence of spots observed on the Sun during these days".
- 245 "From Hervás [...] On the night of the 20th, the sky was tinged with red, which is seen
- at other points, and according to someone, it looked an aurora borealis. Some gullibleand timorous people considered it, no less, a harbinger of war".
- The first news item describes the aurora that was observed from Barcelona starting at 10 p.m (Local Time), attributing it to sunspots. The second news item mentions that the sky turned red over Hervás (Extremadura) at night on 20 February, and also in other unspecified locations.
- 252 Newton and Finch (1951) identified that the sunspot groups responsible for this storm had a maximum area of 2800 millionths of solar hemisphere. Moreover, they also show 253 254 geomagnetic records of this storm. Parker (1951) indicated that the largest magnetic storm in 1950 was that on 19–20 February, but it was not a very great storm. The maximum Kp 255 index was 9-. We found that "The New York Times" reported worldwide radio 256 communications disruptions due to solar and geomagnetic activity (Odenwald, 2021). 257 The report from "Extremadura" informed that this event had a social impact in 258 Extremadura since some people believed that the aurora was a sign of a new war. No 259 260 additional observer descriptions of the aurora were found beyond those published by "Extremadura". 261

FENOMENO METEOROLOGICO

Febrero: Mes que ha satisfeche los deseos de labradores y ganaderos, dejándonos en diez dias de lluvia y cinco de nieve, 93 litros por metro cuadrado, más la reserva por un mes de la nieve que cubre nuestras montañas. Por su parte, las noches frias retraerán la floración, con lo que será más fácil que las frutas sean abundantes.

A mediados de mes, florecen almendros y albaricoques, se ven las primeras cigüeñas y revoletea algún mirlo en las cercanías, que empiezan a preparar sus nídos. En la noche del 20, el cielo se tiñó de rojo, que es visto en otros puntos, y segan algunos, parecia una aurora boreal. Algunos crédulos y timoratos la estimaron, nada menos, presagio de guerra.

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Figure 3. A news article published in "Extremadura" on the geomagnetic storm of
February 1950 with report and Hervás (Extremadura) [Source: newspaper
"Extremadura", 1950].

266 3.4. January 1957

"Extremadura" published three news articles mentioning an aurora in January 1957
(Figure 4). One news item published on 24 January 1957 indicated that the aurora borealis
seen in different places of the planet (including Spanish cities and also mentioning
Vienna) on 21 January was due to an intense solar storm occurred on 20 January. A news
article published on 27 January 1982 reported that an aurora borealis had been seen in
several Spanish cities 25 years ago. Only a news item published on 23 January 1957
includes specific information on the aurora. Its English translation is:

274 "Seville: An aurora borealis was seen in this capital, mainly from the northern sector
275 between the Macarena and the Madrid Road. The red glow spread slowly. The
276 phenomenon lasted about 20 minutes. According to the meteorological service, the
277 phenomenon usually occurs every 12 or 14 years.

- 278 Huelva: A very red cloud appeared over the Molina de la Vega district, in the northern
- 279 part of the city, which began to descend gradually until died out.

Avila: A strange meteorological phenomenon was observed in the northern part of the
city at 11:45 p.m. A red spot covered a large part of the sky and slowly faded away. It is
believed to be an aurora borealis.

283 *Lugo: The whole capital was impressed by a gigantic glow that covered the sky.*

284 Monforte de Lemos: A curious phenomenon was observed in this town. The northern
285 Octave of the West was covered with a rosy glow which is supposed to be a refraction in

space of an aurora borealis with the same characteristics to that occurred in 1956.

Salamanca: In the early hours of yesterday, towards the part of the Pizarrales, a strange
meteorological phenomenon was observed, consisting of a great reddish mantle
extending to a great height".

The aurora was observed from the Spanish cities of Seville, Huelva, Ávila, Lugo, Monforte de Lemos, and Salamanca on 21–22 January 1957. Reports indicated that the aurora was red, visible in the north side of the sky in Seville, Huelva, and Monforte de Lemos. The phenomenon lasted 20 minutes according to the record from Seville, while it is noted that it started at 11:45 p.m. (Local Time) in Ávila. An intense red light was seen in Lugo and Salamanca. Firefighters were mobilized for several hours believing that the aurora was actually a big fire.

297 Paton (1958) highlighted this aurora as one of the three more significant in that year 298 indicating that it could have been seen as an overhead arc in the south of England. Cragg (1958) published solar activity observations with sunspot number values and geomagnetic 299 300 measurements made in 1957. He listed the January 1957 storm as one of the most intense 301 for that year starting on 21 January and ending on 24 January. This storm reached a 302 minimum Dst index of -250 nT at 23 h UT (https://wdc.kugi.kyoto-u.ac.jp/index.html) and the maximum Kp index was 9-. Regarding news published on this storm, "Chicago 303 304 Daily Tribune" informed that a plane crash occurred in the Pyrenees was blamed on the aurora of 24 January 1957 (Odenwald, 2021). 305

We also highlight that the report made in Monforte de Lemos on this aurora indicates that a similar aurora was seen in 1956.





Aurora boreal en Sevilla, nube reja en Huelva 308 y manchas rojizas en Avila y Salamanca

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Figure 4. News articles published in "Extremadura" on the geomagnetic storm of January
1957. News items published on 23 (left) and 24 (right) January 1957 [Source: newspaper
"Extremadura", 1957].

313 3.5. February 1958

Information on two geomagnetic storms in 1958 is included in two news articles, one for February and another for September (Figure 5). That occurred in September 1958 is detailed in Section 3.6. The English translation including the relevant information for the aurora in February is:

318 "On the night of 10–11 February 1958, the crew of the German ship "Beate Bolten" from

319 Hamburg, Germany, sighted an aurora borealis near the Panama Canal. It was the

aurora borealis observed closest to the equator for the International Geophysical Year".

"Extremadura" reported that the closest aurora to the equator seen in the International 321 "Geophysical Year was observed by the crew of the German ship "Beate Bolten" as far 322 south as Panama Canal on 10–11 February. Furthermore, the article provides information 323 on where auroras can be seen and also on the aurora program developed by Germany, 324 including a summary of the aurora frequency and shapes observed for the period 1957– 325 1959. It is indicated that, in that period, German captains sighted about 12 aurorae around 326 327 Spain and even one in the coast of North Africa. In addition, details on observations made by the "Explorer VI" mission and the "Argus" experiment in 1958 are included. 328

Akasofu (1962) defined this storm as exceptional, with DST index values below -400 nT and intense red auroras visible at low, middle, and high latitudes. In particular, the Dst index reached a value of -426 nT on 11 February at 12 h UT and the maximum Kp index was 9. Several newspapers, as "The New York Time" and "Los Angeles Time", reported radio blackouts, telegraph issues, and auroras as far south as Los Angeles (Odenwald,2021).



- Figure 5. News article published in "Extremadura" on the geomagnetic storm of February
 1958 [Source: newspaper "Extremadura", 1961].
- 338 3.6. September 1958

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The news item published in "Extremadura" on 23 June 1959 included information onauroras seen in Germany. Its English translation is:

- 341 "In the Geophysical year, there were 36 magnificent magnetic-terrestrial disturbances
- 342 with corresponding whirlwind in the ionosphere. Five aurorae were observed in northern
- 343 Germany; aurora borealis is also related to the ionosphere. The most wonderful aurora
- 344 borealis was observed on the night of 4–5 September 1958".
- 345 Unfortunately, the only information available on aurorae in this news article is that five 346 aurorae were seen in the northern region of Germany and the most marvelous occurred
- on 4–5 September 1958. We note that 21 aurorae were seen in Germany in 1958 according
- to the article shown in Section 3.5.
- Paton et al. (1959) indicated that this aurora started at 8 p.m. and was widely observed from northern countries to France. These authors noted that, although this aurora was not as brilliant as those occurred on 11 February and 8–9 July, it was spectacular due to its active rayed bands and red pulsating surfaces. Moreover, the minimum Dst index was -302 nT reached on 4 February at 23 h UT and the maximum Kp-index value estimated for this storm was 9- (Schröder, 2011). No information on the influence of this geomagnetic storm was found in other newspapers.
- 356 3.7. November 1991

357 The last significant magnetic storm reported by "Extremadura" occurred in November358 1991 (Figure 6):

359 "Over the last few days, a series of luminous phenomena have been detected in some areas of the Huesca Pyrenees, as well as in Lérida and Zaragoza, which were reported 360 361 to the fire brigade as fires by some people. Indeed, these mysterious phenomena were aurora borealis, a phenomenon that is only visible every 50 years and coincides with a 362 period of high solar activity. Ernest Guill, an astronomer at the Agrometereological 363 Centre of Alta Segarra, explained that 'the first felling you get when you see them is that 364 it is a fire, even when we observed the phenomenon the other night, we initially made that 365 interpretation. But when we looked more closely we began to suspect that it was 366 something else'". 367

The news noted auroras seen in the Pyrenees and in the cities of Lérida and Zaragoza (cities in northern Spain) some nights back. The fire brigade received warnings of possible fires from many people. Thus, we can suppose that the color of the aurora was red. However, no information was provided on the start and duration of the aurora as well as the impact of the geomagnetic storm.

Cliver et al. (2009) classified this storm as one of the largest geomagnetic storms based on the DST index, which reached a minimum peak of -354 nT and a maximum Kp value of 8+. McEwen and Huang (1995) also studied this storm showing that the aurora reached a low-latitude limit of 40° (in geomagnetic latitude) on 9 November. Regarding newspapers informing about this event, for example, "Los Angeles Time" reported that the aurora was visible as far south as Texas (Los Angeles Time, 1991). Regarding the social impact, "Extremadura" reported that many people alerted firefighters about fires.

Aurora boreal

Durante los últimos días, se han detectado en algunas zonas del Pirineo oscense, así como en Lérida y Zaragoza, una serie de fenómenos luminosos que algunas personas denunciaron a los bomberos como incendios.

En realidad, estos misteriosos fenómenos no eran otra cosa que una aurora boreal, un fenómeno que solamente es visible cada 50 años y coincide con un período de gran actividad solar.

Ernest Guill, astrónomo del Centro Agrometereológico de la Alta Segarra, explicó que «la primera sensación que se tiene al contemplarlas es que se trata de un incendio, incluso cuando nosotros observamos el fenómeno la otra noche hicimos, de entrada, esa interpretación. Pero cuando miramos con mayor detenimiento empezamos a sospechar que se trataba de otra cosa».

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- **Figure 6.** News item published in "Extremadura" on the geomagnetic storm of November
- 382 1991 [Source: newspaper "Extremadura", 1991].
- 383 3.8. A suspicious aurora case in 1952
- A news article published in "Extremadura" on 12 February 1952 mentioned the sighting
- 385 of an aurora. The text indicates:
- 386 "A phenomenon of splendor was observed in Hervás [town of Extremadura] on 6 January
- 387 [1952]: the aurora preceding the Sun was formed by concentric arcs with the colors of
- 388 the rainbow".
- Concentric arcs are not typical of auroras, which usually display dynamic and changing arcs. Moreover, red is the most probable auroral color at latitudes as far south as Extremadura (geographic latitudes between 38° and 40°). The mention of rainbow color is unlikely for an aurora. We have also searched for information on possible geomagnetic storms around that date and no records on auroras were found. Therefore, based on the colors and shapes described and the fact that no more records were found, we think that it is highly improbable that this case was related to an aurora.



Figure 7. The 13-month smoothed sunspot number from 1900 until present (green line).
Vertical red lines represent dates on the occurrence of auroras reported in "Extremadura".
Note that the dashed vertical line is because news on two different auroras occurred in 1958 were published in "Extremadura".

401 **4.** Conclusions

The study of solar activity is crucial due to its influence on our society. This activity manifests in phenomena such as sunspots, coronal mass ejections, and auroras. Auroras, more common at high latitudes, but visible at lower latitudes during significant geomagnetic storms, are valuable for studying historical solar behavior. Historical records of auroras provide a valuable dataset for reconstructing long-term solar activity. This work recovers all the information on auroras published in the Spanish newspaper "Extremadura" from 1923 to 2017.

"Extremadura" is a Spanish regional newspaper established in 1923, covering local to 409 410 international news with a focus on Extremadura. In addition to print, it publishes digital 411 content across various sections. For this study, all the issues since its inception were collected digitally. A search for news items on auroras yielded 31 results. These articles 412 413 are categorized into direct observations (12) and general reports (19). The former includes historical aurora events from 1926 to 1991, while the latter covers scientific research, 414 415 explanations of aurora formation, and reports on aurora-related scientific missions and expeditions. Figure 7 shows the relationship between the sunspot number evolution and 416 the occurrence of the auroras reported by "Extremadura". One can see that the auroras 417 reported by "Extremadura". The analysis reveals that the aurora observations occurred 418

around the maximum of solar cycles, specifically during the peaks of Solar Cycle 16 to
19 and Solar Cycle 22. We highlight the importance of auroras as valuable historical
proxies for solar activity.

We scrutinize the news articles in "Extremadura" that encompass specific details on auroras. A condensed overview of these descriptions is presented in Table 1. A simple comparison with the works by Odenwald (2007, 2021) allows us to conclude that the coverage in the "Extremadura" newspaper is not out of the ordinary. Additionally, we incorporate data from other scholarly research and documentary resources on the geomagnetic disturbances that resulted in the auroras documented in "Extremadura", enabling a comparison with the information derived from our principal source.

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437 Data Availability

438 The data used in this work are available on reasonable request to the authors.

439 Author Contribution

JMV organized the work; CSR, LDC and IT extracted the information from the
newspaper; all the author analyzed the data; VMSC wrote the manuscript draft; all the
authors reviewed and edited the manuscript.

443 **Competing interests**

444 The authors declare that they have no conflict of interest.

445 **References**

446 Acero, F.J., Antón, M., Aparicio, A.J.P., Bravo, N., Carrasco, V.M.S., Gallego, M.C.,

447 García, J.A., Tovar, J.A., Vaquero-Martínez, J., Vaquero, J.M., 2024. The anomalous

- thundery month of June 1925 in SW Iberia: description and synoptic analysis. Natural
 Hazards and Earth System Sciences 25, 305. DOI: 10.5194/nhess-25-305-2025.
- Akasofu, S. I., 1962. Large-scale auroral motions and polar magnetic disturbances-II The
 changing distribution of the aurora during large magnetic storms. J. Atmos. Sol.-Terr.
 Phys. 24, 723.
- 453 Anonymous, 1938. The Aurora of January 25–26. Nature 141, 232. DOI:
 454 10.1038/141232a0.
- 455 Aragonès, E., Ordaz, J., 2010. Auroras boreales observadas en la Península Ibérica,
 456 Baleares y Canarias durante el siglo XVIII. Treb. Mus. Geol. Barcelona 17, 45.
- 457 Arlt, R., Vaquero, J.M., 2020. Historical sunspot records. Living Rev. Sol. Phys. 17, 1.
 458 DOI: 10.1007/s41116-020-0023-y.
- 459 Bachiller, R., 2013. 75 años de la aurora de la Guerra Civil, El Mundo,
 460 <u>https://www.elmundo.es/elmundo/2013/01/23/ciencia/1358933296.html</u> (last access:
 461 7 March 2025).
- 462 Carrasco, V.M.S., Aragonès, E., Ordaz, J., Vaquero, J.M., 2018. The Great Aurora of
 463 January 1770 observed in Spain. Hist. Geo Space Sci. 9, 133. DOI: 10.5194/hgss-9464 133-2018.
- 465 Carrasco, V.M.S., Vaquero, J.M., 2020. Portuguese eyewitness accounts of the great
 466 space weather event of 1582. J. Space Weather Space Clim. 10, 4. DOI:
 467 10.1051/swsc/2020005.
- 468 Cliver, E.W., Balasubramaniam, K.S., Nitta, N.V., Li, X., 2009. Great geomagnetic storm
 469 of 9 November 1991: Association with a disappearing solar filament. J. Geophys. Res.
 470 Space 114, A3. DOI. 10.1029/2008JA013232:
- 471 Cragg, T., 1958. Solar Activity in 1957. Publ. Astron. Soc. Pac. 70, 299.
- 472 Clette, F., Lefèvre, L., Chatzistergos, T., et al., 2023. Recalibration of the Sunspot-
- 473 Number: Status Report. Sol. Phys. 298, 44. DOI: 10.1007/s11207-023-02136-3.
- 474 Eddy, J., 1976. The Maunder Minimum. Science 192, 1189. DOI:
 475 10.1126/science.192.4245.118.

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- 476 González-Esparza, J.A., Sánchez-García, E., Sergeeva, M., et al. 2024. The Mother's Day
- 477 Geomagnetic Storm on 10 May 2024: Aurora Observations and Low Latitude Space
- 478 Weather Effects in Mexico. Space Weather 22, e2024SW004111. DOI:
- 479 10.1029/2024SW004111.
- Hapgood, M., 2019. The Great Storm of May 1921: An Exemplar of a Dangerous Space
 Weather Event. Space Weather 17, 950. DOI: 10.1029/2019SW002195.
- 482 Hattori, K., Hayakawa, H., Ebihara, Y., 2019. Occurrence of Great Magnetic Storms on
- 483 6–8 March 1582. MNRAS 487, 3550. DOI: 10.1093/mnras/stz1401.
- Hayakawa, H., Ebihara, Y., Hand, D.P., et al., 2018. Low-latitude Aurorae during the
 Extreme Space Weather Events in 1859. Astrophys. J. 869, 57. DOI: 10.3847/15384357/aae47c.
- 487 Hayakawa, H., Ebihara, Y., Willis, D.M., Toriumi, S., et al., 2019. Temporal and spatial
- evolutions of a large sunspot group and great auroral storms around the Carrington
 event in 1859. Space Weather 17, 1553. DOI: 10.1029/2019SW002269.
- 490 Hayakawa, H., Ribeiro, P., Vaquero, J.M., et al., 2020. The Extreme Space Weather Event
- 491 in 1903 October/November: An Outburst from the Quiet Sun. Astrophys. J. 897, L10.
- 492 DOI: 10.3847/2041-8213/ab6a18.
- 493 Hayakawa, H., Hattori, K., Pevtsov, A.A., et al., 2021. The Intensity and Evolution of the
- 494 Extreme Solar and Geomagnetic Storms in 1938 January. Astrophys. J. 909, 127. DOI:
 495 10.3847/1538-4357/abc427.
- Hayakawa, H., Cliver, E.W., Clette, F., et al., 2023. The Extreme Space Weather Event
 of 1872 February: Sunspots, Magnetic Disturbance, and Auroral Displays. ApJ 959,
 23. DOI: 10.3847/1538-4357/acc6cc.
- 499 Los Angeles Times, November 10 (1991). https://www.latimes.com/archives/la-xpm500 1991-11-10-mn-2148-story.html.
- Love, J.J., 2018. The electric storm of November 1882. Space Weather 16, 37. DOI:
 10.1002/2017SW001795.
- McEwen, D.J., Huang, K., 1995. The polar onset and development of the November 8
 and 9, 1991, global red aurora. J. Geophys. Res. Space 100, A10. DOI:
 10.1029/95JA01299.

- Muñoz-Jaramillo, A., Vaquero, J.M., 2019. Visualization of the challenges and
 limitations of the long-term sunspot number record. Nature Astron. 3, 205. DOI:
 10.1038/s41550-018-0638-2.
- Mursula, K., Holappa, L., Karinen, A., 2008. Correct normalization of the Dst index.
 Astrophys. Space Sci. T. 4, 41. DOI: 10.5194/astra-4-41-2008.
- Newton, H.W., Finch, H.F., 1951. Solar activity and geomagnetic storms, 1950.
 Observatory 71, 45.
- Odenwald, S., 2007. Newspaper reporting of space weather: End of a golden age. Space
 Weather 5, S11005. DOI: 10.1029/2007SW000344.
- 515 Odenwald, S., 2021. The History of Space Weather, independently published.
- 516 Parker, J.M., 1951. Sunspot Activity during 1950. Publ. Astron. Soc. Pac. 63, 76.
- 517 Paton, J., 1958. Auroral activity during 1957. Observatory 78, 219.
- Pulkkinen, T., 2007. Space Weather: Terrestrial Perspective. Living Rev. Sol. Phys. 4, 1.
 DOI: 10.12942/lrsp-2007-1.
- 520 Rico Sinobas, M., 1855. Noticia sobre las auroras boreales observadas en España durante
- el siglo XVIII y parte del XIX. Memorias de la Real Academia de Ciencias Exactas,
- 522 Físicas y Naturales 3, 77.
- Rowland, J.P., 1926. The Magnetic Storm of January 26–27, 1926. Nature 117, 234. DOI:
 10.1038/117234b0.
- 525 Schröder, W., 2011. On the frequency of auroras over Germany. Geofís. Int. 50, 439.
- Silverman, S.M., 1992. Secular variation of the aurora for the past 500 years. Rev.
 Geophys. 30, 333. DOI: 10.1029/92RG01571.
- 528 Silverman, S.M., Hayakawa, H., 2021. The Dalton minimum and John Dalton's auroral
- 529 observations. J. Space Weather SpaC. 11, 17. DOI: 10.1051/swsc/2020082.
- 530 Siscoe, G.L., 1980. Evidence in the auroral record for secular solar variability. Rev.
- 531 Geophys. Space Phys. 18, 647. DOI: 10.1029/RG018i003p00647.
- 532 Usoskin, I.G., 2023. A history of solar activity over millennia. Living Rev. Sol. Phys. 20,
- 533 2. DOI: 10.1007/s41116-023-00036-z.

534 Vaquero, J.M., Gallego, M.C., García, J.A., 2003. Auroras in the Iberian Peninsula (1700-

535 1855) from Rico Sinobas' Catalogue. J. Atmos. Sol-Terr Phys. 65, 677.

- Vaquero, J.M., Trigo, R.M., 2005. Auroras observed in Portugal in the late 18th century
 from printed and manuscript meteorological observations. Sol. Phys. 231, 157. DOI:
 10.1007/s11207-005-1583-7.
- Vaquero, J.M., Valente, M.A., Trigo, R.M., et al., 2008. The 1870 space weather event:
 Geomagnetic and auroral records. J. Geophys. Res. Space 113, A8. DOI:
 10.1029/2007JA012943.
- Vaquero, J.M., Gallego, M.C., Barriendos, M., Rama, E., Sánchez-Lorenzo, A., 2010.
 Francisco Salvá's auroral observations from Barcelona during 1780–1825. Adv. Space
 Res. 45, 1388. DOI: 10.1016/j.asr.2010.02.009.
- 545 Vázquez, M., Vaquero, J.M., Gallego, M.C., Roca Cortés, T., et al., 2016. Long-Term
- 546 Trends and Gleissberg Cycles in Aurora Borealis Records (1600–2015). Sol. Phys.
- 547 291, 613. DOI: 10.1007/s11207-016-0849-6.
- 548 Vaquero, J.M., Bravo-Paredes, N., Obregón, M.A., Carrasco, V.M.S., Valente, M.A.,
- 549 Trigo, R.M., Domínguez-Castro, F., Montero-Martín, J., Vaquero-Martínez, J., Antón,
- 550 M., García, J.A., Gallego, M.C., 2022. Recovery of early meteorological records from
- 551 Extremadura region (SW Iberia): the "CliPastExtrem" (v1.0) database. Geoscience
- 552 Data Journal 9, 207. DOI: 10.1002/gdj3.131.
- 553 Vaquero, J.M., Tovar, I., Gallego, M.C., 2023. A Possible Superbolide Over Don Benito
- (Spain) in 1926 December 27. Research Notes of the American Astronomical Society
 7, 208. DOI: 10.3847/2515-5172/acfe77.
- 556 Vaquero, J.M., Sánchez Romero, C., Díaz-Condiño, L., Gallego, M.C., 2024. A Possible
- 557 Meteoric Fall in Cabeza la Vaca (Spain) in 1970 January. Research Notes of the
- 558 American Astronomical Society 8, 57. DOI: 10.3847/2515-5172/ad2dee.
- Yan, L., He, F., Yue, X., et al., 2023. The 8-Year Solar Cycle During the Maunder
 Minimum. AGU Advances 4, e2023AV000964. DOI: 10.1029/2023AV000964.