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The tornado of Talavera de la Reina on 3 September 1880

V.M.S. Carrasco\textsuperscript{1,2,*}, J.M. Vaquero\textsuperscript{2,3}, A. Ballesteros\textsuperscript{4}, M.C. Gallego\textsuperscript{1,2}, J.A. García\textsuperscript{1,2}

\textsuperscript{1} Departamento de Física, Universidad de Extremadura, Avda. Elvas s/n, 06006 Badajoz, Spain

\textsuperscript{2} Instituto Universitario de Investigación del Agua, Cambio Climático y Sostenibilidad (IACYS), Universidad de Extremadura, Avda. de la Investigación s/n, 06006 Badajoz, Spain

\textsuperscript{3} Departamento de Física, Universidad de Extremadura, Avda. Santa Teresa de Jornet 38, 06800 Mérida (Badajoz), Spain

\textsuperscript{4} Real Academia de Bellas Artes y Ciencias Históricas de Toledo, Calle de la Plata 20, 45001 Toledo, Spain

* Corresponding author: vmcarrasco@unex.es

Highlights:

● An extreme weather event occurred in Talavera de la Reina (Spain) on 3 September 1880

● We conclude it was a tornado analyzing the original record and the synoptic situation

● We rate this tornado as EF2 in the Enhanced Fujita Scale

● It is the first tornado recorded in the region of Talavera de la Reina before 1975.

Graphical abstract:
Abstract

On 3 September 1880, a probable tornado caused significant damage in the city of Talavera de la Reina (Spain). In this work, we analyze the original description made by an observer of that time about this phenomenon and the meteorological conditions for that day. The potential formation of a tornado was possible according to our analysis. This record would be the first tornado recorded in the region of Talavera de la Reina prior to 1975. According to the original description, we could estimate the intensity of this tornado as EF2 (in the Enhanced Fujita Scale).

Keywords: Meteorology; Historical Tornadoes; Tornado climatology; Spanish historical data; Talavera de la Reina.

1. Introduction

Recent studies have shown that extreme weather events, such as tornadoes, are relatively frequent in Spain (Gayà, 2005; Riesco Martín et al., 2015). The number of registered tornadoes has increased in recent decades with respect to past centuries. This fact, however, is not only related to meteorological factors, but also to changes in the perception of society about the importance of recording this type of phenomena (Verbout et al., 2006). For example, Gayà (2011) shows that a clear characteristic in the records of Spanish tornadoes prior to 1826 is that they were mainly registered in regions of Castile and Andalusia. Besides gathering the appropriate meteorological conditions for the tornado formation, these zones possessed a greater population and economic activity.

These events are of great interest due to their direct impact on society (Kunkel et al., 1999). The Enhanced Fujita Scale has been used since 2007 in order to characterize the strength of tornadoes according to the damage caused (Fujita, 1981; Texas Tech University, 2004; Riesco Martín et al., 2015). This scale has six levels, from EF0 to EF5, representing the increase in the impact of damage. Tornadoes labeled as EF0 and EF1 are often referred as "weak", EF2 and EF3 as "strong", and those included in EF4 and EF5 as "violent". Thus, it is necessary to build a database that allows studying the frequency and meteorological characteristics of this kind of phenomena. In this work, we present and analyze the description of a probable tornado that occurred in Talavera de la Reina (Spain) in 1880. In Section 2, we present the documentary
source and the original description of the event. An analysis of this phenomenon is carried out in Section 3. Main conclusions of this work are exposed in Section 4.

2. Documentary Source and Description

The title of an ancient manuscript written by the Jiménez de Castro family (from Talavera de la Reina) is _Antigüedades de esta villa y otras varias_ [Antiquities of this villa and several others] (see Ballesteros, 2015). This work was started by José Jiménez de Castro in the 19th century and continued by his son Pedro. Leopoldo, son of Pedro Jiménez de Castro, stopped its writing in 1908. In 1957, Bernardo Jiménez de Castro y de la Cruz resumed it indicating that neither his father Pedro nor his grandfather Bernardo wrote anything in the manuscript.

This book presents a collection of news articles that happened from the 17th century onwards in the city of Talavera de la Reina (Spain) although several news articles of national interest were also collected. Different information as, for example, on the Basilica of Our Lady of the Prado, celebrations of the city, historical events, and descriptions about meteorological events can be consulted in this book. One of the meteorological events included in this documentary source is a probable tornado that crossed the city in 1880 causing significant damage. The original description of this event is (Fig. 1): “El día 3 de Setiembre del mismo año [1880] hubo un huracán que duró como un minuto, hizo varios destrozos entre ellos fue arrancar varios árboles del Prado [Gardens] y la casa de madera del celador de consumos del puente del río fue volada al río y la varandilla y fue volado el tejado de Dª Germán de la Maza y otros varios tejados de esta población”; [On 3 September of the same year [1880], there was a hurricane that lasted about one minute, it made several damages, among them, to tear several trees from the Prado [Gardens] and the wooden house of the consumption guard of the river bridge and the railing was flown to the river, and the roof of Mr. Germán de la Maza and several other roofs of this city were flown].

3. Analysis

Talavera de la Reina (39º 58’ N, 4º 50’ W) is a city located in the province of Toledo, belonging to the community of Castilla-La Mancha (Spain). Gayà (2011) elaborated on a database of historical tornadoes and no record of this type of meteorological events has been registered in
the Talavera de la Reina area prior to 1975 (Fig. 2). In this way, this case could be incorporated into this tornado database.

In the original documentary source, the meteorological term used to describe the event was "hurricane", which was usually employed in Spain to describe a very strong wind. Moreover, the description also indicates that the duration was approximately one minute. Thus, a tornado or downburst are the meteorological events that best fit to the description. We want to emphasize that the terminology used in the Spanish historical records to characterize this kind of meteorological event is not well defined. In fact, the Royal Spanish Academy of Language did not include the term “tornado” in its dictionary until 1884 (Gayà, 2007). We also note that Lewis and Clark used the term “hurricane” in their journals for damage they observed during their expedition in the period 1803–1806, although that damage could be caused by some sort of high wind event (Preston 2007).

According to the original description, among the damage caused by this extreme event, we found some trees felled in the Prado Gardens and several roofs of the city were ripped. In addition, a railing and a wooden house were uprooted next to the bridge of the Tagus River. These facts increase the probability that it was a tornado. Furthermore, we can classify this event such as “probable tornado” following the categories defined by Rauhala, Brooks and Schultz (2012). Thus, when we mention “tornado” in the text, it refers to this category of “probable tornado”. In Figure 3, the approximate trajectory followed by the tornado is represented on a map of that time. In this map, the places mentioned in the text with a current known location where the tornado caused damage have been indicated: Prado Gardens and the house of the consumption guard of the river bridge. Unfortunately, we do not know the exact location of the house of Mr. Germán de la Maza and all those houses mentioned in the original description that suffered damage. However, analyzing the known areas where this phenomenon had influence, we can confirm that, at least, the eastern half of the city was influenced (Fig. 3).

It is difficult to categorize this historical tornado according to the Enhanced Fujita Scale because we only have a textual report. Among the different damage indicators (ID) that are used to rate an event in the Enhanced Fujita Scale (Texas Tech University, 2004), the damage reported in different houses of Talavera de la Reina could be identified to ID2, ID5, and ID7 and the uprooted trees to ID27 and ID28. For example, regarding ID2, the fact that large sections of roof structure were removed in several houses fits to the degree of damage number 6, which is associated to wind speed equal to 196 km/h (122 mph) (Texas Tech University, 2004, p. 8). The
recommended Enhanced Fujita Scale in this case would be EF2 (Texas Tech University, 2004, p. 11). Considering ID27 and ID28, the uprooted trees in the Prado Gardens would indicate that at least we can associate it to wind speed of 210 km/h (131 mph). Therefore, taking into account this analysis, we could estimate this tornado as EF2, that is within the tornadoes considered as "strong" (Texas Tech University, 2004; Riesco Martín et al., 2015). This estimate would suppose that the intensity of the tornado occurred in Talavera de la Reina in 1880 would be less than in the historic Spanish tornadoes of Cádiz (1671) and Madrid (1886). In the old Fujita Scale, the tornadoes of Cádiz and Madrid were estimated as F4 (wind speed around 267–322 km/h) and F3 (wind speed around 219–266 km/h), respectively (Gayà, 2007, 2011). Unfortunately, these events caused deaths. While in Madrid the victim number was counted by tens, in the case of Cadiz it is not exactly known since documentary sources suggest that the number could range between several tens and more than six hundred (Sánchez-Laulhé, 2005).

Riesco Martín et al. (2015) studied the climatology of 224 tornadoes recorded in the Iberian Peninsula and the Balearic Islands between 2003 and 2012. These authors exposed the typical meteorological conditions for the formation of tornadoes in the interior of the Iberian Peninsula. According to this study, the typical vertical profile of the peninsular interior is very dry at low levels during the summer, so the heating is very efficient. In the case of a significant cooling in middle layers, for example, with temperatures of -12º C in 500 hPa, large amounts of CAPE (abbreviations of Convective Available Potential Energy) can be developed and cause severe storms. These storms usually have relatively high bases which limits the occurrence of tornadoes. However, if a tornado occurs, it can reach a high intensity (Riesco Martín et al., 2015). A historical example of this type of meteorological events is the 1886 tornado of Madrid previously mentioned (Gayà, 2007).

In order to contextualize the synoptic conditions corresponding to the day of the tornado (3 September 1880), Figure 4 shows maps for the European region of: temperature on surface (panel A) and at 500 hPa (B), mean sea-level pressure (C), CAPE (D), relative humidity at 1000 hPa (E) and 500 hPa (F), specific humidity at 1000 hPa (G) and 500 hPa (H), and u-v components of wind speed at surface (I and K) and 500 hPa (J and L). These maps were obtained from the online tool "20th Century Reanalysis V2c data" (Compo et al., 2011) provided by the National Oceanic and Atmospheric Administration (NOAA, http://www.esrl.noaa.gov/psd). Moreover, meteorological conditions on days of severe thunderstorm and tornado events can be highly variable between the morning and afternoon hours and therefore we have represented in those maps values from the reanalysis for the tornado day at 18:00 UTC. According to these
reanalysis maps, for the tornado day, the mean sea-level pressure on the center of the Iberian Peninsula was around 1017 hPa. Although the original description does not mention anything about storm or raining, it usually accompanies to the tornadoes. We obtained information about meteorological observations of precipitation for provincial capital cities next to Talavera de la Reina: Toledo (capital of the province where Talavera de la Reina is placed), Caceres, and Salamanca. In Gaceta de Madrid (1880, p. 750), Section “Dirección general de Correos y Telégrafos” is exposed (Fig. 5A): “Según los partes recibidos, ayer llovió en Almería, Cáceres, Pontevedra, Salamanca, Soria, Toledo y Valladolid” [English translation: According to the report received, yesterday, it rained in Almeria, Caceres, Pontevedra, Salamanca, Soria, Toledo, and Valladolid]. Furthermore, observations about several meteorological variables made at Madrid Observatory were also regularly published in Gaceta de Madrid. We found that the maximum and minimum temperature recorded at Madrid Observatory on the tornado day (3 September 1880) was 30.0 °C and 16.5 °C, respectively, with a measured precipitation of 0.5 mm (Fig. 5B, center panel). In the previous day (Fig. 5B, left panel), the maximum and minimum temperature was 28.8 °C and 17.6 °C without precipitation (0 mm) and 28.3 °C and 15.8 °C with 2.8 mm of precipitation for the following day to the tornado day (Fig. 5B, right panel). Therefore, we found that tornado day was raining in those cities and thus, probably, it also rained in Talavera de la Reina (Fig. 5).

In addition, according to the reanalysis maps, the surface temperature in Talavera de la Reina at 18 h UTC was approximately 30 °C and about -10 °C at 500 hPa, fulfilling in this way one of the conditions given by Riesco Martín et al. (2015) for the formation of tornadoes in the interior of the Iberian Peninsula. Regarding the surface temperature in Madrid for the tornado day, we highlight that data from the reanalysis (Fig. 4A) is in agreement to observational values (Fig. 5B). In Figure 4, it can be seen that the Iberian Peninsula is the only European region with a significant CAPE index for the day of the tornado. Specifically, in the area of Talavera de la Reina, the value of this index was approximately equal to 1100 J/kg on 3 September 1880. The maps show that the relative humidity values in Talavera de la Reina was around 50 % at 1000 hPa and 65 % at 500 hPa for the tornado day. Furthermore, in general, the Iberian Peninsula had the greatest values for the specific humidity in Europe both at 1000 hPa and 500 hPa. Thus, it also fulfilled that the availability of humidity was enough for the tornado formation.

The 0–6 km bulk wind shear is used in severe convection researches (Monteverdi, Doswell and Lipari, 2003; Pilorz et al., 2016). This parameter is calculated by determining the difference in wind speed between the surface and at six kilometers height (around 500 hPa). In order to
estimate the bulk wind shear for the tornado day in Talavera de la Reina area, we computed the wind speed \( V \) at surface and 500 hPa from \( u \) and \( v \) components of wind speed obtained from reanalysis data (Fig. 4I-L) so that:

\[
V = \sqrt{u^2 + v^2}
\]

The wind speed value at surface is low (around 2 m/s) and it would not be compatible for the formation of a tornado. Moreover, we have obtained a 0–6 km bulk wind shear value roughly 4.7 m/s. We acknowledge this value is also low. For example, it would be around 25-percentile found by Pilorz et al. (2016) for weak tornadoes recorded in Poland for 2011–2015. However, we highlight that the wind and shear in a particular place can undergo significant changes in minutes and it is hard to estimate for historical tornadoes. We also note that the wind speed in the \( v \) component at surface and 500 hPa is similar and no change in the direction of the wind can be found. However, we can see a change in the \( u \) component. In this case, the wind speed increased from -1 m/s (at surface) to 6 m/s (500 hPa) and, moreover, we can see that there is a change in the direction of the wind because it is from the east at surface and from the west at 500 hPa.

4. Conclusions

In this work, we analyze the description of an extreme weather event that occurred in Talavera de la Reina (39º 58' N, 4º 50' W) in the year 1880. In the historical catalogue of tornadoes in Spain carried out by Gayà (2011), no tornadoes had been recorded in the area of Talavera de la Reina before 1975. Therefore, this record could be incorporated into this historical database. In a modern study made by Riesco Martín et al. (2015) for the period 2003–2012, tornadoes were not also registered in the Talavera de la Reina region. It means that this zone is not a typical area for the appearance of tornadoes.

Although the event is defined as a hurricane in the original source, due to its short duration (approximately one minute) and the damage caused, the most likely meteorological event is a tornado. Furthermore, according to Rauhala, Brooks and Schultz (2012), we can classify this event such as “probable tornado”. The damage caused by this tornado were several roofs of the city and trees uprooted, in addition to tear off a railing and a wooden house next to the Tagus River. Given this scenario, this tornado could be rated as EF2 according to the Enhanced Fujita Scale. This would mean that the wind gusts of this tornado could have reached 179-218 km/h.
The maps of the meteorological variables obtained from the online tool "20th Century Reanalysis V2c data" provided by NOAA, indicate for the area of Talavera de la Reina on the tornado day: a) and b) temperatures about 30 °C on the surface and -10 °C at 500 hPa, respectively; c) a mean sea-level pressure around 1017 hPa; d) a CAPE index approximately equal to 1100 J/kg; e) and f) relative humidity roughly of 50 % at 1000 hPa and of 65% at 500 hPa; g) and h) the greatest values of specific humidity of Europe. On the other hand, we have obtained low values of bulk wind shear with a significant change only in the u component, but we acknowledge it is really hard to assess for historical tornadoes because of the significant changes shear can undergo in minutes in a particular location. Furthermore, after consulting the meteorological observations of the province capital cities close to Talavera de la Reina (Toledo, Caceres, Salamanca, and Madrid) on the tornado day, we think that, although the original description does not indicate it explicitly, it rained in Talavera de la Reina that day since in those cities that day was rainy. Thus, we can conclude that the synoptic situation analyzed in this work on 3 September 1880 in Talavera de la Reina adjusts to the conditions for the tornado formation.

Finally, we want to highlight that it is very important to know the occurrence frequency of these extreme events and meteorological conditions given for its formation. This information can help us to reduce the damage caused by these phenomena. For this reason, we must continue with the task of improving and incorporating information relative to historical tornadoes in the databases currently available.

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**Disclosure of Potential Conflicts of Interest** The authors declare that they have no conflicts of interest.

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Centro Nacional de Información Geográfica. Talavera de la Reina Map for 1884 available at: http://centrodedescargas.cnig.es/CentroDescargas/index.jsp#.


El día 5 de Septiembre del mismo año hubo un
Huracán que duró como un minuto, hizo varios des
la casa de madera del edificio de consigo,
del puente del río fue rodado al río y la vaca dita,
y fue rodado el tejar a de 3. Semana de la elvada y
otra varias tiendas de esta población.

Figure 1. Original description included in Antigüedades de esta villa y otras varias on the
tornado of Talavera de la Reina on 3 September 1880 [Courtesy of the Basilica of Our Lady of
the Prado].
Figure 2. Tornado geographic distribution for the period 1826–1975 in red triangles. Blue ellipse represents the location of the Talavera de la Reina area [Source: Gayà, 2011].
Figure 3. Map of Talavera de la Reina dated in the 1880’s [Source: http://centrodedescargas.cnig.es/CentroDescargas/index.jsp#, Centro Nacional de Información Geográfica]. Dots 1 and 2 represent locations of the consumption guard of the Tagus river bridge and the Prado Gardens, respectively. These locations are the two known places mentioned in the original description. Dashed line depicts the possible trajectory of the tornado.
Figure 4. Meteorological situation in Europe for the tornado day (3 September 1880) in Talavera de la Reina: temperature on the surface (A) and at 500 hPa (B), mean sea-level pressure (C), CAPE (D), relative humidity at 1000 hPa (E) and 500 hPa (F), specific humidity at 1000 hPa (G) and 500 hPa (H), and u-v components of wind speed at surface (I and K) and 500 hPa (J and L).
Figure 5. (A) Reports about Spanish cities with raining conditions for the tornado day [Source: Gaceta de Madrid 248, p. 750]. (B) Meteorological observations made at Madrid Observatory on 2 (left), 3 (center), and 4 (right) September 1880 [Source: Gaceta de Madrid 247 (p. 738), 248 (p. 750), 249 (p. 762)]. (C) Locations of provincial capital cities next to Talavera de la Reina (1) where there was rainfall conditions for the tornado day: Toledo (2), Caceres (3), Salamanca (4), and Madrid (5).