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The first meteorological measurements in the Iberian Peninsula: evaluating the storm of November 1724

F. Domínguez-Castro · R. M. Trigo · J. M. Vaquero

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Abstract Early instrumental series can play a key role in the study of recent climate change or assessments of specific extreme events. Unfortunately in the Iberian Peninsula few series are available relative to the 18th century. In this article we retrieved and make available the first daily instrumental series obtained in Iberia. The observations were made in Lisbon between 1 November 1724 and 11 January 1725 by Diogo Nunes Ribeiro. While pressure and temperature values were registered twice a day, the remaining variables, i.e. the state of the sky, wind direction and force, have only one value per day. Despite the relatively short period covered by this series, we were very fortunate to discover that it helps to characterize one of the strongest storms that struck Lisbon since the early 17th century. In particular, the data provide evidence for an outstanding pressure drop of 28.61 hPa from 1010.76 hPa on the 18 November to just 982.15 hPa on the 19 November. Using recently digitized pressure data for Lisbon since 1863, we can state that this 24 h decrease of surface pressure has been surpassed only once on the 28 November 1879. Moreover, the extreme winds associated with this "bomb" affected severely the entire Lisbon area as well as large sections of central and northern Portugal during the afternoon of 19 November and caused important damage in the eastern coast of Madeira the night before (18 November). This storm resembles the rare tropical storms that have reached the Iberian Peninsula as a tropical storm (Vince 2005) or the low intense hurricane that occurred in 1842.

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F. Domínguez-Castro (✉) · J. M. Vaquero
Departamento de Física, Universidad de Extremadura, Badajoz, Spain
e-mail: f.dominguez.castro@gmail.com

R. M. Trigo · J. M. Vaquero
IDL, Universidade de Lisboa, Lisbon, Portugal

R. M. Trigo
Departamento de Eng. Civil da Universidade Lusófona, Lisbon, Portugal

1 Introduction

The early instrumental (EI) series, i.e. series obtained prior to the founding of National Meteorological services, represent a great opportunity for climate studies. On the one hand these series are useful to study the climatic variability before the industrial revolution (Camuffo and Jones 2002), including climate extremes associated with natural variability phenomena such as El Niño (Können et al. 1998). Moreover, these EI series are increasingly used as a reference to constrain and calibrate proxies that can provide, if properly calibrated, information from much earlier times (Büntgen et al. 2011). Thus, it is of no surprise that the discovery, digitalization and homogenization of new EI time series have played a key role in international projects funded by the European Union, such as IMPROVE (Camuffo and Jones 2002) and MILLENIUM (Brázdil et al. 2010) and the ongoing ERACLIM (http://www.era-clim.eu/).

The EI have been widely used to study the climate variability in locations from late 17th century such as London (Cornes et al. 2012a), Paris (Cornes et al. 2012b), Florence, Bologna, Parma, Pisa, Milan or Cutigliano (Camuffo and Bertolin 2012a) and several more since the early 18th century in Italy, e.g. Padua (Camuffo and Bertolin 2012b), central Europe, e.g. Prage (Brázdil et al. 2012), and Scandinavia, e.g. Stockholm (Moberg et al. 2002), Uppsala (Bergström and Moberg 2002), St. Petersburg (Jones and Lister 2002); also this series have been combined to analyze regional climate (Manley 1974; Moberg et al. 2000; Böhm et al. 2001; Demarée et al. 2002; Camuffo et al. 2010, 2012; Brázdil et al. 2012). Additionally, several authors have used EI datasets to understand case studies such as volcanic eruptions (Trigo et al. 2009), tropical depressions and hurricanes (Vaquero et al. 2008; Chenoweth and Landsea 2004; Wheeler et al. 2009) or large mid-latitude storms (Pfister et al. 2010).

Unlike other parts of Europe, there are very few references to available meteorological observations in Iberia prior to 1750 (Alcoforado et al. 2012). Early daily meteorological observations known for the Iberian Peninsula start at the end of 18th century, namely in Barcelona at 1780 by the Doctor Francisco Salvà y Campillo (Barriendos et al. 1997); Mafra (close to Lisbon) at 1783 by Joaquim da Assunção Velho (Alcoforado et al. 2012) and Cadiz at 1786 by Jerónimo Sánchez Buitrago (Barriendos et al. 2002). To the best of our knowledge, this work retrieves the earliest daily instrumental observations acquired in the Iberian Peninsula. These daily measurements were obtained in Lisbon between 1 November 1724 and 11 January 1725.

It should be noted that there are only a handful of daily series in the world that are contemporaneous to these observations: Francis Hauksbee in London (Cornes et al. 2012a), Giacomo Filippo Maraldi in Paris (Cornes et al. 2012b), Erik Burman in Uppsala (Bergström and Moberg 2002), Jacopo Bartolomeo Beccari in Bologna (Comani 1987), Johann Kanold in Wroclaw and Christian Heinrich Erndtel in Warsaw (Przybylak 2010).

The meteorological readings described in this paper have value per se in the sense that they correspond to one of a very short list of available daily measurements at this time. Nevertheless, their mere academic interest is significantly amplified due to the occurrence of a very strong storm on 19 November 1724 for which we have been able to recover several additional documents describing the damage caused.

2 The observer in Lisbon and his colleague in London

The meteorological observations have been found in a letter wrote by Isaac Sequeira signed in London the 3rd March of 1725 (Julian calendar) (the letterhead and data relative to the observations obtained in October 1724 are included as Online Resource 1). This letter was addressed to James Jurin. We think that the letter is a reply to the request by James Jurin to take meteorological observation published in the *Philosophical Transactions* (Jurin 1723), because the observation methodology and the instruments used were those recommended by Jurin in this article. The original letter entitled "Weather observations from Lisbon for October to December 1724 by Isaac Sequeira Samuda" is maintained in the archive of the Royal Society (reference number Cl.P/5/34).

Isaac Sequeira Samuda was born in Lisbon in 1696. He studied Medicine at the University of Coimbra and obtained his degree on 21 May 1720. Soon afterwards he was admitted in the Royal College of Physicians in London on 19 March 1721. He was a doctor of the Portuguese Embassy and had the honorary title of Physician Extraordinary to the Prince Regent of Portugal (Esaguy 1936). He was admitted to the Royal Society on 27 June 1724, under the presidency of Isaac Newton. He is one of the 25 Portuguese who have been members of the Royal Society and the first Jew to be elected to the fellowship (Fiolhais 2011).

Isaac Sequeira Samuda was particularly fond of the astronomic and mathematical sciences, and he was often requested by other Portuguese scholars to present their results (*in absentia*) at the Royal Society. In fact, he delivered at the Royal Society presentations which were forwarded to him from Portugal by astronomer João Baptista Carbone (1694–1750) and other Portuguese and foreign Jesuit scholars. The date of the Sequeira Samuda dead is not clear with different sources giving different dates 1730 (Hyamson 1951), 1731 (Esaguy 1936) or 1743 (Landman 1969), but his obituary in the London Magazine of April 1743 as "Dr. Samuda an eminent Jew Physician" do support the date put forward by Landman (1969). We must stress that Sequeira was not the observer of these measurements because he was living in London when the readings were obtained. However, his role in this study (gathering the information obtained in Lisbon and presenting it to the Royal Society) is sufficiently relevant to deserve some biographical information.

According to the observations header (see Online Resource 1), the observer was "Doctor Jacobo Nunes Ribeyro", in reference to Dr. Diogo Nunes Ribeiro (1668 Idanha A Nova—1744 New York), later known as Samuel Nunes. Diogo was a prominent physician and belonged to a respected family from the north-central province of Beira. His father served as a procurator of the Customs House and several family members practiced medicine (Greenberg 2002). He was appointed Court Physician to the King of Portugal. Among his prominent patients were Dominicans and the Grand Inquisitor. He was the uncle of the great intellectual Dr. Antonio Nunes Ribeiro (Penamacor, 7 March 1699–Paris, 14 October 1783) and was determinant in Antonio's decision to study medicine (Doria 2001).

To facilitate the reading of this work we will refer to the observed dataset simply as ID (Isaac and Diogo).

3 The observed variables

The meteorological observations provided in the letter are relative to instrumental measurements obtained from 21 October to 31 December 1724 in Julian calendar, this period correspond in Gregorian calendar to 1 November 1724 to 11 January 1725. The used instruments were made by Francis Hauksbee, considered the official of the Royal Society at this time (Middleton 1966).

The meteorological variables observed were: pressure, temperature, wind direction, wind force and state of the sky. The barometric and thermometric measurements were taken twice a day. The first measurement was obtained in the morning between 6 a.m. and 10 a.m. with 89 % of the measurements observed at 8 a.m. The second measurement was obtained in the early afternoon at 2 p.m. The state of the sky, the wind direction and force, were measured only once a day.

3.1 Temperature

The temperature measurements were taken using the Hauksbee scale. We have converted these readings to the Celsius scale taking into account the equivalences showed in Van Swinden (1778).

Figure 1a shows the ID temperature register (green) in comparison with the long-term register of the classical Lisbon station (38º43′, 9º9′, 77 m.a.s.l.) during the most homogenous period 1941–1993 (blue and red). The ID observations falls well within the typical evolution of temperatures for this time of the year showing a general trend to lower temperatures during winter, and oscillating mainly between the mean maximum and minimum temperature of the recent period. On the other hand the relatively negligible difference between the two ID daily records is indicative that the measurements were taken indoor, following the recommendations of James Jurin (1723).

3.2 Barometer

The barometer was made Francis Hauksbee and the scale used in the ID observations is the English inch. The Francis Hauksbee barometer is a cistern barometer, with characteristics within the square and the diagonal barometers. In the Hauksbee barometer a small glass tube is joined to the cistern and extends upwards at a small angle to the horizontal, acting as a gauge, for the height of the mercury in the cistern (Middleton 1964). The pressure has been corrected in order to take into account the temperature and latitude effect, unfortunately we cannot correct for the height effect because we do not know where the observatory was located.

The pressure ID measurements have been compared with the pressure register of Lisbon (1941–1993) at 9 a.m because this is the time most completed and is closer to the ID first observational time. The evolution of the ID pressure time series falls well within recent climate variability (Fig. 1b), although the average for that period (1011.5 hPa) is somewhat higher than the average for the 1941–1993 period (1009.6 hPa). The standard deviations of the two data sets are very similar (8.3 and 7.5, respectively). However, two factors undermine these statistical values, first the volume of data in the recent series is much higher (more than 50 years) and secondly, the ID series is not corrected for altitude. Taking into account that the 1941–1993 measurements are corrected at 0 m.a.s.l., a difference around 2 hPa between the early and 1941–1993 measurements could point out that the early observatory was at around 19 m.a.s.l. This height fits well with the range of altitude of most houses located in the urbanized areas of Lisbon in the early 18th century (0–50 m), however the short time series available implies a large uncertainty on this result. In any case ID measurements are consistent with those obtained for the recent climate. Nevertheless, one cannot disregard the large pressure drop that took place on 19 November, particularly visible for the second measure of the day. In fact, as clearly observed in Fig. 1b, this value corresponds to the lowest pressure data recorded for any 19 November in Lisbon since 1941 (although lower values have been observed in mid November). This day was characterized by the appearance of a strong storm that is discussed in detail below.

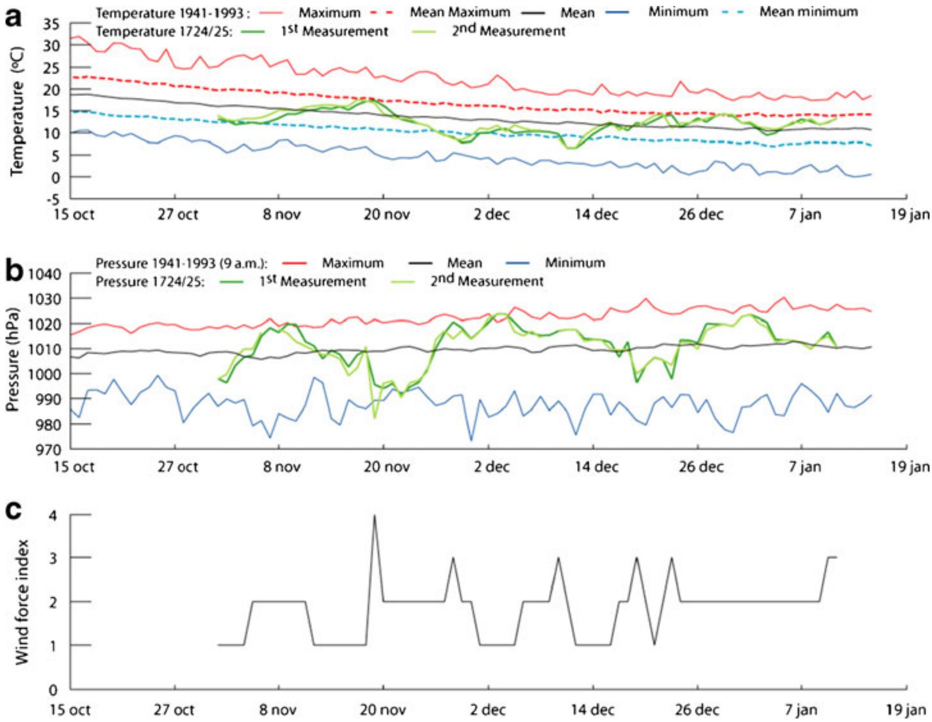


Fig. 1 ID record from 1 November 1724 to 11 January 1725: **a** Temperature (*dark green line* first measurement, *light green line* second measurement). For comparison purposes we show the corresponding long-term observations obtained at the classical Lisbon station between 1941 and 1993: *continuous red line* (absolute maximum), *red dashed line* (mean of maximum), *gray line* (average), *dashed blue line* (mean of minimum) and *continuous blue line* (absolute minimum) (**b**) Pressure (*dark green* first measurements, *light green* second measurements). For comparison purpose we show the corresponding long-term observations obtained at the classical Lisbon between 1941 and 1993 at 9 a.m.: *red line* (maximum pressure), *grey line* (mean pressure.) and *blue line* (minimum pressure) (**c**) Wind force index

3.3 Wind force

The wind force was measured using the simple scale recommend by Jurin (1723) that varies between 0 and 4. The wind force obtained in ID's observations, between 1 November and 11 January 1725, is shown in Fig. 1c. It is immediately noticeable that the wind force reached level 4 on 19 November 1724. According to this scale, wind force of category 1 corresponds to a gentle breeze that shakes with difficulty the trees leaves, while the top level 4 corresponds to a really violent wind.

The most frequent category during the period was 2 (59.7 %), followed by class 1 (30.5 %), while the windiest classes appear less often, namely category 3 (8.3 %) and only 1 day characterized by a category 4 force index (19 November).

4 What happened on the 19 November 1724?

4.1 A longer term perspective on the intense drop on atmospheric pressure

It is now clear that a particular intense storm passed over Lisbon on the 19 November 1724, and was recorded during the relatively short period of data obtained by ID. In order to further investigate this we now analyze in greater detail the evolution of meteorological parameters during the peak of the storm, i.e. the sequence of days leading to it and immediately afterwards (Fig. 2). The 19 November storm is characterized by a large drop of surface pressure. According to the second measurement of ID's registered at 2 p.m. the pressure fell 28.61 hPa from 1010.76 hPa on the 18 November to just 982.15 hPa on the 19 November. Interestingly, the observer (Diogo) was sufficiently aware of the unusual meteorological conditions (associated with this significant drop of pressure) that he took the decision to perform a third "unusual" measurement on that day. Thus if we consider the third observation obtained at 4 p.m (973.71 hPa), than the total pressure drop from the previous day reaches the extraordinary value 37.05 hPa in 26 h. As we have commented above the 19 November was the only day characterized with a category 4 in the wind force scale. On the other hand the evolution of temperatures appears to be less affected by the passage of the storm, nevertheless we must bear in mind that the measurements were taken indoor, decreasing the sensibility to rapid changes.

In order to put this remarkable pressure drop into a longer temporal perspective, we have analyzed the largest decreases of atmospheric pressure in 24 h (between consecutive measures at 9 am) in Lisbon during the entire 1863–2006 period. This recently digitized surface pressure time series has been analyzed in detail prior to its inclusion in the 20th century Reanalyzes dataset (Compo et al. 2011). In fact, looking closely at the largest 5 drops of atmospheric pressure for Lisbon in 24 h it must be stressed that the only occasion with a larger decline corresponds to the 28 November 1879, when the barometer fell 31.8 hPa in 24 h (Fig. 3).

The storm of 19 November 1724 was characterized by such a large drop of atmospheric pressure over Lisbon that it corresponded most probably to the passage of a fast deepening storm, often named "Bomb" (Sanders and Gyakum 1980). Bombs are rapidly deepening extratropical surface cyclones with a pressure fall in the depression centre at sea level of at least (24·sinϕ/sin60º) hPa in 24 h (Liberato et al. 2011). This corresponds to 24 hPa at latitude 60ºN in 24 h (Trigo 2006). A geostrophically equivalent rate at 45ºN corresponds to 19.6 hPa.

4.2 The impacts of the storm on land and sea

Thanks to a document found in the Royal Society entitled "Extracts from two letters with details of a violent storm in Lisbon and Gibraltar" dated 23 November 1724 (Royal Society Archive, reference Cl.P/4i/72), we can provide some additional details of the damages

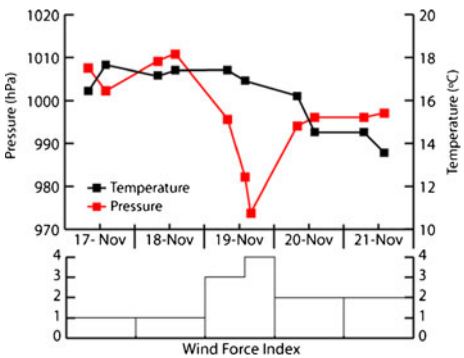
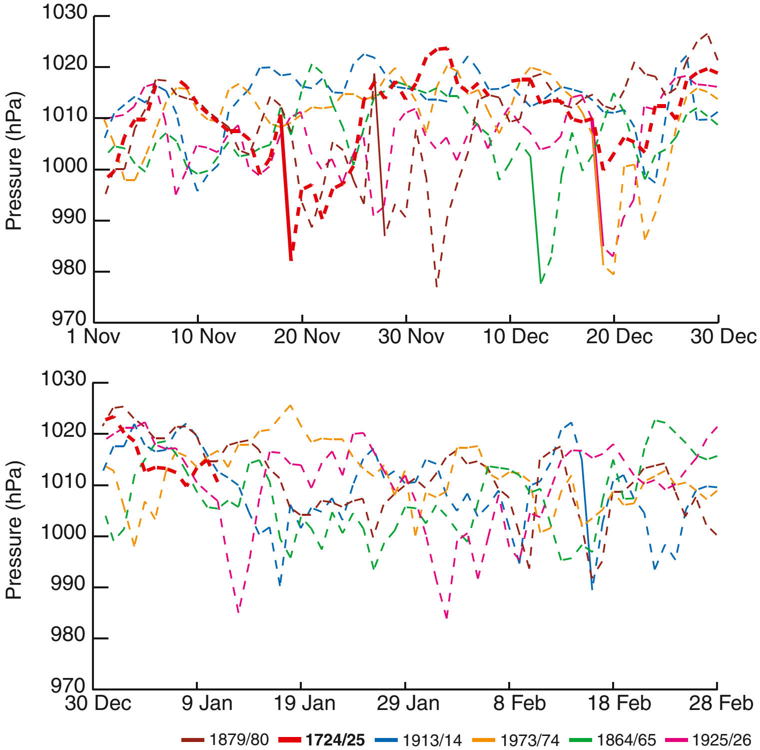


Fig. 2 The evolution of surface pressure, temperature and wind force in Lisbon between 17 November 1724 and 21 November 1724



Day	28/11/1879	**19/11/1724**	16/02/1914	19/12/1973	13/12/1964	19/12/1925
Pressure (hPa)	987	**982.2**	989.4	981.4	977.8	985.0
Difference preceding day (hPa)	-31.8	**-28.6**	-25.5	-25.3	-24.9	-24.9

Fig. 3 Temporal evolution of atmospheric pressure between November and February for the 5 years characterized by the largest 24 h drops in pressure. The *solid line* marks the largest decreases. Unfortunately the drop of 1925/26 is not visible because it took place on the very same day of the 1973/74 event, i.e. 19 December

caused by the 19 November 1724 storm in the Lisbon area: "*The 19 of this month at 16 p.m. start a furious hurricane from the east and midday, during 3 h long*"…"*19 instant in the afternoon, being them rainy to earlier, at one o'clock a South-East wind with small rain begun to be high, and continued till three o'clock, when one and other element augment their force"*. The letter than describes that this storm had an unusual magnitude: *"The most violent storm that ever was known in these parts, the oldest man alive never saw other like…wind with such strength that this day will be memorable for any ages"*. The storm caused important damages on land: *"Wall fell, houses was ruined the glazes of churches and palaces broken"*. The letter mentioned some specific places affected by the storm *"In the garden of the Earl of Aveiras a great number of trees, pots and statues were destroyed. The great cross of red marble that for many years had resisted to the violence of winds on the hill of St. Catharina was drawn out of his basis. The same happened to many more in this city, as that upon the steeple of the monastery of the Trinity, that fall. Several tops of steeples were broken. Part of the monastery of St Vicente de Fora, Graça, and St Chistovão fell"*. In any case, the contents of these letters reveal that it was at sea where the storm produced the greatest damages:

> "…*But nothing of this* (inland damages) *is comparable to that at sea. The ships were forced from their anchors and broken one against another. Some were sunk; some drove a shore, where the violence of the waves made them in pieces. The water, beat the wall, with such a force that not only demolish them; but of that called of Santarém stones were thrown as far as the palace of the Earl of Coculim, and by the side of Boa vista the raised water fall like rain as distant as the monastery of Bernardas and St. Bento.*
> *Da pedra, and the custom house bridge* [ponte da Alfandega] *were demolished. From the house where is the officine of guns* [praia da Casa Real da Fundição] *to the tower of Belém, being two leagues, can nor be seen but lamentable ruins of ships lost and merchandises expulsed by the wave. The Kings warships received damages and should be destroyed if with more vigilance was not helped. Seventy two ships of several nations were cast away, and among them some Portuguese laden with goods for the Brazil being many so ruined that only the keels remain.*
> *More than 120 were sunk, and driven at shore. Is not known the number of persons that were drowned; it is said that 160 was drove to shore"*
> *…"¾ of the ships in the river were forced from their anchors, and drove a shore, where at least 50 sail we believe will remain for they will not be able to get them off again: almost all the boats in the river are destroyed, in so much that there is nothing but wreaks to be seen from Belém to Marvilla, which is two leagues*".

Also the country suffers the effects of the storm *"almost half the trees of all sorts are blowing down*". In summary "*damage has caused is incredible, and some millions of crusades wont repaired"*... "*it is a general calamity, that has been felt all the kingdom over"*.

Similar damage descriptions were published in national (*Gazeta de Lisboa Occidental* Nos. 47 (23/11/1724), 49 (7/12/1724) and 50 (14/12/1724)) and international Gazettes, e.g. *Gazeta de Madrid,* No. 49 (05/12/1724). According to *The London Gazette* No. 6327 (5-8/12/1724), the financial damages provoked by the storm were very serious, and advancing an estimate "*The damages by this tempest, is generally computed to exceed a Million Sterling*".

Over land, the damage caused by this extreme event was not limited to the Portuguese capital, since a large number of locations in the center of the country (mostly located north of Lisbon) also suffered significant damage in buildings, sunk boats, falling trees, etc. as shown in Fig. 4a (damages descriptions are included as Online Resource 2). Moreover, the damage caused by the storm started before arriving to the Lisbon area as we have also obtained descriptions of the event in the island of Madeira the night before the arrival of the storm to Lisbon (November 18), especially on the east coast of the island (Fig. 4b) and summarized here:

> *"On the evening of this day (November 18), year 1724 the island of Madeira was stricken by such a large storm and great flood that destroyed the town of Machico (26 people death and more than 80 houses ruined), part of the small town of Santa Cruz, and many other places in the same island, and also the city of Funchal has experienced great damage and ruin in their walls, as well as in the city centre due to the flood of the small river that divides it* [Ribeira Pinheiro]". (Da Silva and Azevedo 1940).

Although Madeira and central-northern Portugal were the most affected areas by the storm, the atmospheric instability during these dates was evident in other places as:

- Gibraltar: Extract of a letter from Gibraltar of the 24 November 1724 (Royal Society Archive, reference Cl.P/4i/72). "*Last Monday, being the 20th of November, we had here*

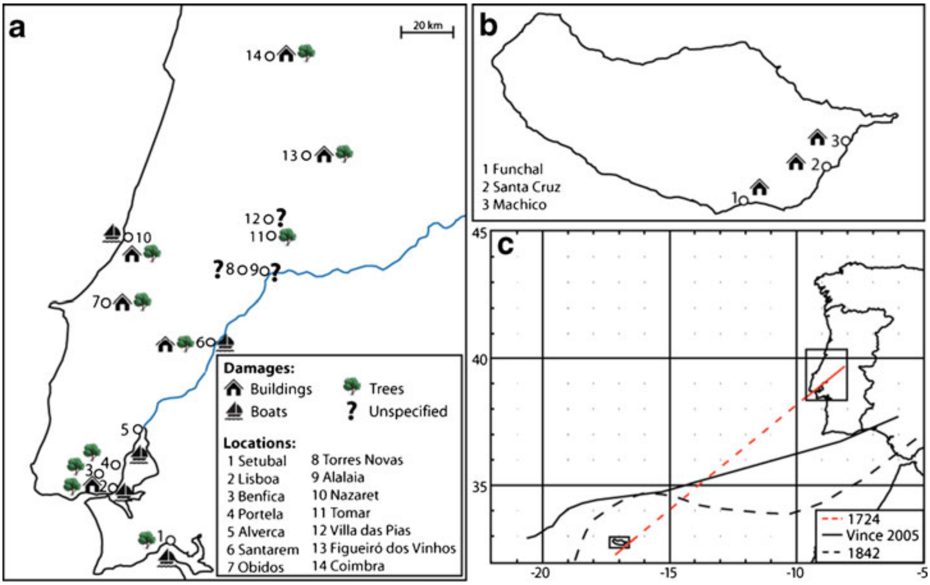


Fig. 4 **a** Locations affected by the storm in continental Portugal (**b**) Locations affected by the storm in Madeira (**c**) Trajectory of hurricane Vince according to Franklin (2006), 1842 trajectory estimation by Vaquero et al. (2008)

a very great storm of hail. The stones were each every way proportional to the circumference of a crown piece, and weighed upwards of four ounces. Some persons told me there were those, which were much bigger then what I had seen. I took particular notice that some of them were sharp pointed, and came down with such violence, that they did not look so big, but seemed to gather matter, and congeal in the air, when coming down. They had holes in the middle of the biggeness of common hail, but what was more surprising, they had four or five impressed circles round them. This storm continued about half and a quarter of an hour. Several windows and even the tilings of houses were broken; and boar to pieces. The grass in the fields where it fell, was burnt and destroyed. An old gentleman informed me, that at Algecires about 35 years ago, there fall hail stones as big as the crown, and killed a vast number of cattle."

- São Miguel Island: During the 19 November seven merchant ship were lost (Da Conceição 1820).
- Cadiz: Two warships left Cadiz on 23 November and returned to port sinking (one to Cadiz and the other to Málaga) due to a great storm. (Gazeta de Lisboa Occidental No. 50 (14/12/17249)).
- Geneva and western Mediterranean: In a letter wrote in Geneva the 22 November 1722 we can read "The heavy and continuous rainfalls and the rough sea of these days have not led to receive the post from Spain and have caused some damage in our coast (Savona, Italy)." (Gazeta de Madrid No. 51 (19/12/1724)).

As explained above the great storm of 19 November 1724 was characterized by a sufficiently strong enough pressure fall to be considered a "Bomb" (Sanders and Gyakum 1980). In fact the largest drop in pressure could have been even stronger to what was detected in Lisbon, as it may have occurred over the ocean, before arriving to Portugal. Taking into account the devastating effects inland and in the ocean it must be considered also as one of the most destructive storms ever to occur in the history of Portugal. An incomplete list of these destructive storms includes the following cases: 1600, 1639, 1732 (15 October), 1739 (December), 1941 (15 February), 1967, 1981 (December) or 1983. A detailed study of the 1739 event is presented by Taborda (2006). The cost of the damaged caused by intense (but relatively rare) wind storms in Portugal can be very high, as was the case of the damages caused by the 15 February 1941 storm. According to a recent report from the Insurance industry, the cost of this event in Portugal alone reached the equivalent of around 5 Billion of Euros in 2009 (Muir-Wood 2011).

4.3 Could this event correspond to a tropical cyclone?

The majority of great windstorms affecting Portugal correspond to mid-latitude Atlantic intense cyclones that have undergone an explosive cyclogenesis phase (Bombs). These relative rare events are favored by the prevalence of the negative NAO phase, favoring the occurrence of favorable conditions at lower-than-usual latitudes (Trigo 2006), such as the recent destructive storm Klaus (Liberato et al. 2011). However, the probable trajectory of the 1724 storm could bear more resemblance with those rare cases of tropical storms that reach Iberia, as was the case of Hurricane Vince 2005 (Franklin 2006) and its analog 1842 (Vaquero et al. 2008). Other possible rare case occurred in November 1826 was reported by Betencourt and Dorta (2010).

Vince is described by Franklin 2006 as "category 1 hurricane (on the Saffir-Simpson Hurricane Scale) that became the first known tropical cyclone to reach the Iberian Peninsula. It also became a hurricane farther east than any other known Atlantic basin tropical cyclone." Vince was designated as hurricane on the 9 October when it was located at 34.1ºN 18.9ºW then began to weaken reaching the southwest Iberia as a tropical depression (Fig. 4c).

The 1842 Vince analogue was also formed in the eastern Atlantic Ocean and moved east-northeast towards the southwest of Iberia, through a similar storm track to that produced by Vince (Fig. 4c). But the 1842 storm arrived to the Iberian coast with more intensity and caused more damages than Vince.

The 1724 storm was most likely formed also in the eastern Atlantic Ocean, although southern than Vince because when moving to northeast it affected seriously the eastern coastal sector of Madeira (unlike Vince and the 1842 storm). The storm reached the Iberian Peninsula close to Lisbon, i.e. farther north than Vince and the 1842 analogue did (Fig. 4c).

The description of damages, the maxima category in the wind strength index, the large drop in surface pressure measurements and the description of the storm as "*Ephnefia maxima*[1]" or "hurricane" in contemporary texts suggests that this 1724 storm is another analogous of hurricane Vince. Probably when the 1724 storm arrived to Lisbon it had characteristics of tropical storm or of a low hurricane category similar to the 1842 landfall.

Although the evidences compiled suggest that the 1724 storm corresponds more appropriately to a tropical cyclone rather to an explosive mid-latitude "bomb", further data collection at sea would be needed to determine the storm track and the synoptic situation associated to the storm to confirm our hypothesis.

[1] According to Bernhard Varenius (1734) "*The Ecnephia is a strong and sudden wind that breaks out from some cloud; which is frequent in the Ethiopic Sea* [south Atlantic]*, between Brazil and Southern Africa; especially at the Cape of Good-Hope, and on the other Side of Africa, at Terra de Natal and at Guinea, under the Equator. The Portuguese call them Travados, the Latins Procella, but the Greeks word Ecnephia is the most appropriate: they are most frequent in certain places, and in certain months of the year*".

5 Final remarks

This paper made available the earliest daily observations acquired in the Iberian Peninsula (http://salva-sinobas.uvigo.es/index.php/eng/). These measurements were taken in Lisbon by Dr. Diogo Nunes Ribeiro from 1 November 1724 to 11 January 1725 following the methodology recommended by James Jurin.

Although these observations cover only a short period they have been providential to characterize the very strong storm that hit Lisbon during the 19 November. This storm was one of the most destructive ever experienced in Portugal since the early 17th century. The pressure drop observed in 24 h was one of the most intense ever recorded, after an objective comparison with all the largest pressure drops observed in the last 150 years, since the implementation of daily measurements the Lisbon station in 1863. Taking into account the probable trajectory of the storm, namely its passage slightly to the south of Madeira island in the previous day, we argue that this storm corresponds most likely to a rare tropical cyclone similar to Vince in 2005 and its analogue of 1842. Despite the impressive descriptions of destruction of ships in coastal waters, the majority of evidences compiled here correspond to inland evidences. Therefore we do not know the storm track with sufficient accuracy and further studies are required to confirm this possibility.

The observations retrieved in this paper highlight two important question regarding to the meteorology in Portugal, first the important role played by medical Doctors in the first stages of the meteorology in Portugal, as well as in Spain (Dr. Fernández Navarrate and Dr. Salvà y Campillo). In fact, it is quite probable that further early meteorological documentation can be found in medical institutions that remain unexplored for these purposes. Secondly little is known about Diogo Nunes Ribeira and most of the studies where his name appears are related to his condition of new Christian. However, we argue that our study provides sufficient information so that this man can be consider an important milestone in the implementation of meteorology science in Portugal, employing the highest standards used at the time.

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