

*The “Little Ice Age” (LIA) in Europe – particularly
Portugal (an attempt at a synthesis)*

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A Brief Context

The Modern Age and the beginning of the Contemporary period were deeply marked by a climatic worsening known as the Little Ice Age (LIA). Although with different intensities and peaks of incidence, its greatest influence seems to happen in the Northern Hemisphere. Here, due to the vastness of the matter, we only address the case of Europe. As this climatic phase can be defined through glaciological and climatic criteria, its chronology of occurrence is not consensual. In the European case, despite different proposals for chronological marking, the “LIA” would have taken place between the end of the “Medieval Warm Period” (MWP) and the second half of the 19th century (1300-1850). “LIA” was mainly due to a combination of natural factors that impacted the lives of people at that time. The expansion of volcanic activity and the consequent increase in dust and gases in the atmosphere (preventing solar penetration), combined with phases of lower incidence of solar radiant energy on the Earth’s surface and the deceleration of thermohaline circulation in the North Atlantic, contributed to changes in patterns thermal and rainfall. In general, in the Northern Hemisphere, win-

ters have become harsher and summers have become colder. It is estimated that the average annual temperatures reached values between 0.6 and 1 degrees Celsius lower than the average recorded for the 20th century. At first reaching the highest latitudes, the cooling process expanded to Southern Europe, reaching particularly lower temperatures during the main periods of solar minimums (fig. 1), namely between the years 1280-1350 (Wolf Minimum), 1460-1540 (Spörer's Minimum), 1645-1715 (Maunder's Minimum), and 1792-1820 (Dalton's Minimum). This situation resulted in intense climatic variability including periods of intense cold with snow storms, avalanches or heavy rainfall and floods, but also periods of heatwaves and droughts (Luterbacher et al., 2001, Mann et al., 2009; Brázdil et al., 2010; Miller et al., 2012; Luterbacher & Pfister, 2015; Camenisch; Rohr, 2018; Oliva et al., 2018).

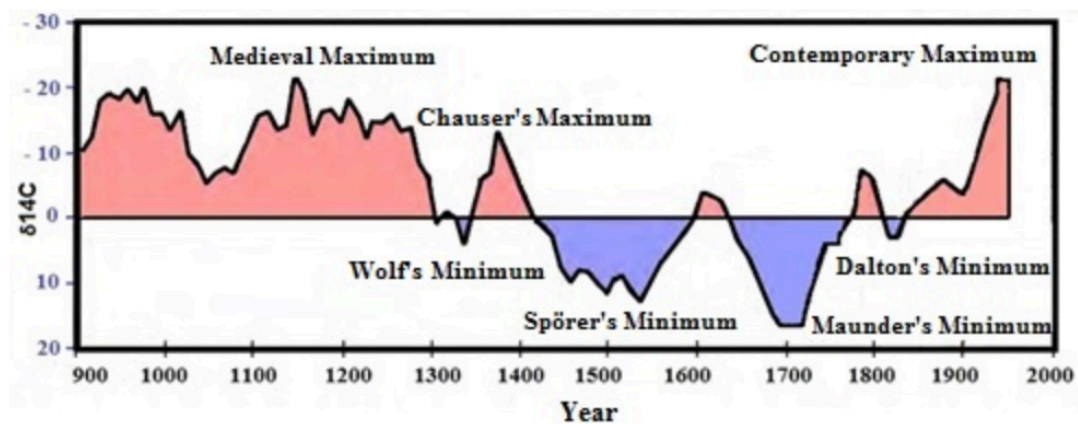


Figure 1: Oscillation of $\delta^{14}\text{C}$ records recorded in tree growth rings as an indicator of sunspots and consequent climatic periods between the years 900 and 2000 (Adapted from Dias, 2016, p. 61).

Throughout Europe

It is relatively consensual that in the 14th century, a progressive European cooling began, and with it the LIA. At various points, such as in Southern Europe, in addition to the average cooling, extreme weather events were recorded: *i.e.* high rainfall in winter, with huge floods that destroyed crops and brought hunger to populations. During the Spörer Minimum (1460-1540), low temperatures became more intense, with a succession of severe winters in Central Europe and periods of floods in the Mediterranean region of the Iberian Peninsula. Until the beginning of the 17th century, temperatures remained relatively low and there were several

episodes of heavy rainfall. In Central Europe, summers for a few decades were the coldest in memory. It was around this time, with the combination of low temperatures and high humidity, that glaciers expanded into European mid-latitudes (Pfister et al., 1998; Camenisch et al., 2016; Oliva et al., 2018).

With the proximity of the Maunder Minimum (1645-1715) the weather conditions tended to worsen. On average, there was a decrease in temperature and worsening of the rainfall regime, which contributed to the emergence of socio-economic problems (Camenisch et al., 2016; Oliva et al., 2018). During this climatic phase, the period after 1680 stands out and mainly the decade from 1691 to 1700, which had the lowest temperatures of the millennium. In several European regions there have been phenomena of snowfall where it rarely happened, or its permanence for unusually long periods of time. The fair that took place over the river Thames (river Thames Frost Fair), when its waters froze during the winter (fig. 2), was well known. The freezing of this river was not frequent, but during the Maunder Minimum, it froze four times between 1649 and 1666, allowing the fair to take place (Lockwood et al. 2017; Oliva et al., 2018).

With the end of the Maunder Minimum and the increase in solar radiation, temperatures rose again, but from the 60s and until the end of the 18th century, there was a further deterioration in weather conditions with strong impacts on agriculture due to destruction of crops by the rigor of the weather. Periods of famine once again raged in European kingdoms, with epidemic outbreaks such as that of malaria in the Iberian Peninsula (Oliva et al., 2018). This fact could have boosted the emergence of popular revolts and the likelihood of bellicose confrontations. It is in this context that the “hunger riots” or “bread riots” take place in England and France. In short, we can say that the lack of cereals for the manufacture of bread, the basis of contemporary food, which is associated with the tax increase by the privileged social strata (high clergy and nobility) as a way to mitigate the decrease in income, created the “perfect storm” and triggered a series of social revolts that, in France, led to the emergence of the French Revolution in 1789. Between the end of the 18th century and the 20s of the following century, with the period of the Dalton Minimum, conditions got worse again. At this stage there were volcanic eruptions that, combined with low solar radiation, lowered the temperature. Extreme weather events followed, such as periods of prolonged drought, intense floods and cooler summers (Brázdil et al., 2010; Luterbacher & Pfister, 2015; Oliva et al., 2018).



Figure 2: Abraham Hondius, A Frost Fair on the Thames at Temple Stairs. Oil painting, 1684, (32 x 19 cm). Available: <https://www.museumoflondonprints.com/image/139609/abraham-hondius-a-frost-fair-on-the-thames-at-temple-stairs-1684> ou <https://upload.wikimedia.org/wikipedia/commons/6/62/A-Frost-Fair-on-the-Thames-at-Temple-Stairs-1684.jpg>

The “Little Ice Age” in Portugal

The different intensities and climatic periods observed all over Europe were obviously also felt in Portugal. The final centuries of the Middle Ages were particularly difficult. Periods of famine, pestilence and wars raged in the country at the same time that climatic conditions deteriorated, leveraged by the Wolf’s Minimum (1280-1350) and Spörer’s Minimum (1460-1540) periods. The seasons of the year were colder and with high rainfall, with particular incidence on the Atlantic coast and mountainous areas. In the peninsular register, two periods of concentration of episodes of torrential rain occurred between 1310-1330 and between 1360-1390. In the 15th century, the climate continued to cool, with an expansion of glaciers in the highest points of the Iberian Peninsula, as well as several snow storms (Diaz et al. 2011; Moreno et al. 2012; Oliva et al. 2018).

In the Maunder Minimum stage (1645-1715), the “LIA” intensified in Portugal. Periods of very low temperatures and extreme events have multiplied (Alcoforado et al. 2000). In Lisbon,

for example, the month of January had rain, snow and strong winds causing landslides and killing people (Gazeta do Mês de Janeiro, 1642, p. 5).

Particularly difficult times seem to have occurred between the year 1663 and 1665. Especially in summer, extreme thermal variations and periods of heavy rainfall caused flooding and various damage, causing the ruin of agricultural crops. In the Coimbra region, winters were very cold and rainy, interspersed with snow and strong winds that also hit the region, causing high damage and flooding in the Mondego river (Daveau, 1997). In Minho, in the valley of the river Lima, the month of October was very rainy, causing floods (O Mercurio Português, October 1663). In Lisbon, the Tejo river also climbed its banks. The rigors of winter also reached the Alentejo region, where, at the beginning of 1665, it rained the entire month of January. In the region of Guarda, rain and storms were added to temperatures that reached very low values, causing deaths (O Mercurio Português, January 1665). These conditions of intense cold, heavy rains and dry summers were identified all over the country, in a chronological duration that lasted until around the year 1716. Although the relatively stable period recorded in Europe between the end of the Maunder Minimum (1645-1715) and the Minimal beginning of Dalton (1792-1820), in Portugal some extreme events were still felt (Alcoforado et al. 2000; Oliva et al. 2018; Silva, 2019). In the Douro river, for example, heavy rainfall caused flooding several times throughout the 18th century, causing damage to riverside locations, destroying boats, houses, crops, among many other damages (Amorim et al. 2017). The same episodes also occurred in other river courses such as the Tâmega river, the Mondego river, the Tejo river or the Guadiana river, resulting in similar consequences. In summer, periods of drought were frequent and sometimes quite prolonged, making it impossible to plant or harvest foodstuffs, especially cereals (Daveau, 1997; Taborda, 2006; Silva, 2019). These periods of drought were also registered in other areas of the Iberian Peninsula or in Europe, contributing to situations of food shortage that led to epidemic outbreaks such as malaria. Finally, climate variations throughout the 18th century caused several problems in the country, particularly aggravated by the following period of the Dalton Minimum (1792-1820), during which large volcanic eruptions occurred, influencing the change in the North Atlantic Oscillation index. Summer temperatures have dropped to around 2 degrees Celsius in parts of the Iberian Peninsula. Especially between the years 1815 and 1835, several extreme events such as floods and prolonged droughts took place (Oliva et al., 2018).

Reminiscent of Elsa from the movie Frozen, the Modern Period and the beginning of the Contemporary, seems to have suffered from the perverse spell of recording phases in which a magical touch would freeze the kingdom and ruin its inhabitants.

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