Considerations about the production of a monthly precipitation and mean temperature database for Amadora (Portugal)

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Abstract: This communication presents the methodology adopted for the project Local Campaign UNISDR 2010-2020 "Always in Motion, Amadora is Resilient!", in order to obtain a monthly precipitation and temperature database for Amadora (Portugal). The precipitation database goes back to October 1915 and the mean temperature database goes back to October 1939. The climate data obtained would aim at the following various purposes: (i) to support a detailed analysis about the evolution of the precipitation and mean temperature in Amadora; (ii) and support other studies, such as those related to urban floods, car accidents, forest fires, or landslides. The communication approaches the information that was necessary to collect, the steps adopted to improve data quality, and all the procedures that were implemented to produce monthly values of precipitation and mean temperature in Amadora. It is important to mention that there were no meteorological stations or valuable climate data available in Amadora.

Keywords: Precipitation. Temperature. Climate database. Amadora. UNISDR.

1. Introduction

It is extremely important to study the precipitation and temperature of any region, given, on one hand, its role in the different stages of the hydrological cycle, or other climate-related cycles, and on the other hand, in natural events such as floods, droughts, or forest fires, presently increased by our climate change context (Rodrigues, 2016) (Brázdil, et al., 2018) (IPCC, 2018) (Ganho, 2019) (Fonseca, 2020).

However, there was no valuable climate data available for the Amadora municipality. Amadora's Civil Protection Service had a weather station and possessed some climate data, however, it was just for a short period and many abnormal values were identified. Therefore, to build a database and to obtain climate data for Amadora, specific procedures adopted. As a result, a sequence from October 1915 to September 2021 was obtained for monthly precipitation and a sequence from October 1939 to September 2021 was obtained for monthly mean temperature.

Amadora is one of the 18 municipalities of the Lisbon Metropolitan Area. It is situated in the northern part of Lisbon, about 10 km away from the Atlantic Ocean. It is surrounded by other municipalities, such as Lisbon (Southeast), Oeiras (South), Sintra (West and North), and Odivelas (Northeast).

There are no significant hills in Amadora. Most of the territory is between 51 and 250 meters above sea level, with about 60% situated between 100 to 200 meters. Slopes also tend to be insignificant. Serra da Mira, with 273 meters, is the most important hill.

The variability throughout the year of the precipitation in Amadora, and in general, in mainland Portugal, is related to the fact that it is located in a transitional zone between subtropical highs, in the south, and low-pressure systems, in the north (Leal, 2019). During the winter, Amadora is under the influence of low-pressure systems and frontal systems, which are usually associated with humid air masses and atmospheric instability. During the summer, subtropical highs and their warm air masses determine hot, dry, and stable weather conditions on the surface. The passage of humid air masses is related to an air current that blows from west to east, at a few kilometers in altitude (a jet stream) and which is responsible for the displacement of the polar front and of different air masses on the surface (Medeiros, 2000) (Oliveira, et al., 2017).

Since the Atlantic Ocean is close to Amadora, higher values of precipitation are more common here than in other areas at the same latitude, such as those closer to Spain (Rodrigues, 2016). However, since there are no significant hills in Amadora, these values are not higher as they are in mountainous areas (Leal, 2019).

2. Conceptual and methodological framework

If climatology is the study of climate, and its variations and extremes, climate can be defined as "the average weather conditions for a particular location and period of time (…) and can be described in terms of statistical descriptions of the central tendencies and variability of relevant elements such as precipitation or temperature" (WMO, 2018).

Presently there is a lot of climate data available from the last 70 years, but not much from the XIX century or the first decades of the XX century. Although meteorological observations in Portugal began in the 1770s, they were mainly about floods or major storms (Silva, 2019).

In order to obtain climate data (monthly precipitation and monthly mean temperature), it was necessary to collect existing information from two main sources: (i) Portuguese Water Resources Centre (SNIRH, https://snirh.apambiente.pt), 26 meteorological stations; (ii) Portuguese Institute for Sea and Atmosphere (IPMA, https://www.ipma.pt), 5 meteorological stations. The furthest meteorological station is Vila Nogueira de Azeitão, 32.9 kilometers away from Amadora.

Using data from 33 meteorological stations allowed comparison and exclusion of abnormal values. It would be better to use only data from meteorological stations located in the Amadora municipality, but there are no such stations, or the ones that existed in the past had poor quality data.

Therefore, the calculation of climate data for the Amadora municipality can be summarised into the following steps: (i) loading data from 33 meteorological stations (from SNIRH and IPMA); (ii) identifying and correcting abnormal values through comparisons with all the monthly values available and specific algorithms; (iii) correlating and filling missing values using all the data available and setting priority according to the highest correlation; (iv) interpolating values to obtain a new final value for Amadora that is calculated according to precipitation or temperature, and distance from some meteorological stations to the Amadora municipality.

It is important to mention that the 5 IPMA meteorological stations were adopted as reference stations. This choice took into consideration the quality of their climate data, longevity, and proximity to the Amadora municipality. The interpolation mentioned previously has considered only these 5 stations.

A high correlation was observed between the 5 IPMA stations (1. Cabo Raso – Farol; 2. Lisboa – Gago Coutinho; 3. Lisboa – Portela; 4. Lisboa – Tapada da Ajuda; 5. Sintra – Granja) and all the other stations. For precipitation, in most cases, correlations are above 90% and, many times, even above 95%. For temperature, the lowest correlation is 95%, but most of the time varies from 98 to 99%.

Sometimes, and despite having collected data from 33 meteorological stations, there were months without any value for precipitation and/or mean temperature. In those cases, the precipitation or the mean temperature was obtained getting the mean value of the existing values of the station. These values represent less than 0.5% of all the monthly data available.

4. Results

First, it is important to mention that hydrological years were used instead of civil years. Hydrological years are closer to the climate cycles that usually succeed in Portugal (Nascimento, 2017) and start on October 1st and end on September 30th.

106 years of monthly precipitation data and 82 years of monthly mean temperature were obtained. The annual mean precipitation is 685 mm and the annual mean temperature is 16.4°C.

Table 1 – Annual and monthly mean precipitation/temperature, Amadora (Portugal)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Annual
Precip. (mm) 1915/2021	75	102	99	96	82	78	57	43	15	4	5	29	684
Max. precip. (mm) and year	227 1990	345 1983	345 1989	352 1996	297 1947	223 1916	182 2000	144 1996	86 1970	35 1988	35 1976	122 2014	------
Mean temp. (°C) 1939/2021	18.1	14.2	11.5	10.9	11.7	13.4	15	17	19.9	21.7	22.2	21	16.4
Max. | Min. mean temp. (°C)	15.3 20.9	11.1 | 16.8	7.6 | 14.0	8.4 | 13.3	7.5 | 14.0	11.2 | 17.1	11.4 | 18.8	13.7 | 19.9	16.4 | 22.2	19.5 | 23.8	20.0 | 24.9	18.4 | 23.2	------

The month with the highest precipitation is November (102 mm), followed by December (99 mm). The rainy season goes from October to April. These 7 months are responsible for 86% of the annual precipitation. The driest months are July (4 mm) and August (5 mm) and combined represent 3% of the annual precipitation.

Some of the months have registered in the past up to 3 or 4 times the mean precipitation. Most of these episodes such as January 1996 or November 1983 were related with floods in Amadora and/or in the river Tejo drainage basin (Quaresma, 2008) (Loureiro, 2009) (Leal, 2019). Precipitations near 0 mm were also registered for all the months and they were related with the permanence of subtropical highs, for long periods (Medeiros, 2000) (Miranda, et al., 2006).

The rainiest hydrological year was 1995/1996, with 1238 mm, followed by 1968/1969 (1179 mm) and 1997/1998 (1046 mm). The driest hydrological year was 2004/05, with 263 mm, only 38% of the average precipitation. 1944/45 (290 mm) or 1982/83 (383) were very dry as well.

Regarding temperatures, January is normally the coldest month (10.9°C) while August is generally the warmest (22.2°C). However, lower values than 10.9°C were registered in the past. February 1956, the coldest month ever, registered a 7.5°C mean temperature since mainland Portugal was under the influence of a very cold air mass with a continental route, that was moving around a vast high-pressure system located south of Iceland (IPMA, 2020c). Higher temperatures than the average monthly value were also registered in the past and they are becoming more common in the present. For example, February and July 2020 were the hottest February and July on record since October 1939.

Regarding annual values, 1947/48 was the hottest hydrological year, with an average temperature of 17.5°C. 1966/67, on the other hand, was the coldest year, with 13°C. Three different periods were identified: (i) higher temperatures in 40s and 50s; (ii) lower temperatures in the 60s, 70s and 80s; (iii) higher temperatures since the 90s. Similar observations were documented in other studies (Miranda, et al., 2006) (Alçada, 2017).

5. Conclusions

It is important to do or to promote, at a local level, the collection, treatment, systematisation, and analysis of climate data. Considering the financial, material, or human resources, normally scarce at this level of analysis, it is important not only to develop, but also to reflect upon the adoption and simplification of methodological procedures, which may allow the production and availability of climate databases.

Several constraints were identified during the construction of the database, which should not be omitted. Older periods have less data available. Sometimes, only one meteorological station had data available. In other cases, although few, no station presents data. This kind of situation should be avoided.

The procedures adopted for the construction of this precipitation and mean temperature database tend to produce data and results that are consistent with other similar studies. Both the methods developed, as well

as the selected meteorological stations and their respective data, always had, as a selection/exclusion factor, high correlations (normally above 0.9).

The database produced has special relevance for the Amadora's Civil Protection Service, as it helps to contextualise, situate, and even to project situations (e.g., floods) for which the services have to be prepared.

The obtained data seems to fit the Intergovernmental Panel on Climate Changes' conclusions about climate changes. There is a clear increase in the annual mean temperature and, at the same time, a decrease in the annual precipitation. And there is not only less precipitation but also a shorter period of rain, so the ecosystems are experiencing a drier and a longer drier period.

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