Tornadoes in Portugal

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ABSTRACT

In Portugal, research on tornadoes is relatively recent but it has already shown that these phenomena are not as rare as believed by the public and even scientific opinion. As tornadoes only affect a small area, the probability of them being observed at a meteorological station is very small. Thus most of the existing records are people's recollections, some descriptions in newspapers, and some photos. It has been possible to find data on 30 tornadoes that occurred between 1936 and 2002, and the database is being continually updated. All of the cases found thus far have ranged from moderate to strongly devastating, some of them causing great damage. The strongest tornado in Portugal happened in November 1954 and was a T7 event. Occurrences of less intense tornadoes are almost certainly underestimated. Since 2000, a more careful look for reports has revealed the existence of some weaker tornadoes.

Tornadoes in Portugal occur mainly from October to January along severe cold fronts or line squalls. Most cases were in association with deep depressions to the west of Portugal, when there was a moist and warm strong to gale force south-westerly flow and generalised severe weather over the country. Some cases happened in a very unstable westerly flow.

There are also records on summer tornadoes, developing within strong thunderstorm cells. These cells often develop into mesoscale convective systems resulting from strong heating over the centre of the Iberian Peninsula.

INTRODUCTION

It was believed that tornadoes either did not occur or were very rare in Portugal. However, the truth is that a database on tornadoes in Portugal did not really exist.

When a tornado occurred on April 21st 1999, at Vila do Conde, it was reported to the Meteorological Institute. With photographic evidence proving that this tornado had happened (see Figure 1) it became the subject of a case study (Coelho and Leitão, 2000).

Whilst working on this study, the author became aware that other tornadoes had occurred in Portugal before. Photographs of four previous tornadoes from the private collections of meteorologists, a barograph record from a tornado that destroyed the meteorological station of Castelo Branco on November 6th 1954, data from newspaper reports (Costa Alves) and a report on a devastatingly strong wind event (Nunes, 1996) provided further clues about the tornado phenomenon in Portugal, which resulted in this current research.

Since tornadoes are micro-scale phenomena the probability of being observed from a meteorological station is very small and thus, there are no records from the official Portuguese meteorological database. The objective of this research has been to record the number of tornadoes and their data through the "forgotten memories" of the public. This research is ongoing but up to the time of writing, 30 tornadoes have been recorded between 1936 and 2002. There is also data on a further 14 events but these could not be confirmed.

RESEARCH METHOD

For this research all the available data on possible events about tornadoes was collected: photographs, data from private collections of meteorologists, meteorological reports on the effects of strong winds, research in local newspapers, visits to the localities and information from local authorities and the public.

Often the occurrence of a tornado is reported in local newspapers, which thus becomes an important source of data. Sometimes there are also official reports on the damage caused. However, these descriptions are not scientific. They do not provide important details on the meteorological phenomenon and may not distinguish damage caused by the tornado and damage due to other severe weather conditions or even the consequences of human action.

But a tornado is a very severe phenomenon, and if someone witnesses a tornado, even a weak one, they will never forget that experience! Even several years later it is possible to get a good description from an eyewitness. Talking to people about severe weather and strong winds often reveals further clues on new events.

Each event was subject to exhaustive research to collect all the available information in order to record: locality, day and hour of the occurrence, intensity, width and length of the path, damage caused and injuries to people. In some cases it was impossible to acquire all the data.

A number of cases could not be confirmed as tornadic and recognising a tornado is not always easy. When the funnel cloud is witnessed, and there is a photo or a very clear description there is no problem in classifying the event. Even so, a

very weak tornado may be similar to a land devil topped by a small cumulus (Wakimoto, 1989).

For several reasons few tornadoes are observed in action (Elsom, 1985):

- there may be no potential eye-witnesses present,
- night-time may prevent them being witnessed,
- or direct line of sight of a tornado may be obscured by precipitation, buildings or trees.

In these cases a careful observation of the effects is needed.

The evidence that is sought in order that a tornado may be recorded includes (Elsom, 1985):

- a narrow path of damage
- the explosive or suction effects
- the shear effects
- heavy objects lifted and/or lighter objects carried long distances
- an unusually sustained roaring noise.

However less strong tornadoes do not always show these obvious effects. A damage path can also be caused by a downburst or other strong wind. Additionally, a tornado path can be embedded in a broader area of damage caused by a strong wind (Fujita, 1981; Forbes, 1983; Dessens,1988; Bunting and Smith, 1993).

DATA ANALYSIS

The research resulted in a comprehensive set of records for 30 tornadoes from 1936 to 2002.

Tornadoes have been reported all over Portugal, except over the mountainous area of the northeast, but most of them were near the coast, as shown in Figure 2. There are 3 confirmed records of waterspouts moving inland.

From 1987 to 2002 there is a record almost every year of at least one tornado, see Table 1. There are records of tornadoes occurring throughout the year (see Figure 2) but 56% of the events occurred during October, November and December. There are also records of more than one tornado on the same day. On July 30th 2001 a strong downburst, a T1 (F0) and a T3 (F1) tornado were recorded over an area 30 km long, during a period of one hour.

There is very incomplete data on the path of 11 events, see Table 2. This analysis shows that most path lengths are between 3 and 6 km, but there are paths longer than 11 km.

The intensity calculated from records of the effects of 27 events is based on the Fujita (Fujita, 1981) and TORRO (Meaden, 1985) scales. The most reported intensity is T4 (F2), as shown in Figure 3. The most intense event on record was the T7 (F3) event in November 1954 that resulted in 5 deaths. This research initially concentrated on the strong and "unforgettable" events, while the weaker occurrences of tornadic activity, causing less damage, were under-estimated. All the records on T1 and T2 tornadoes were dated after this research began, when more attention was paid to these weaker events.

METEOROLOGICAL SITUATIONS WITH TORNADOES

For 19 events, a first sight analysis of the synoptic pattern was performed. It was possible to recognise three meteorological situations favourable for the development of tornadoes:

The most common involves a cold front, or a severe line squall, crossing the country in association with a deep low to the west of the Iberian Peninsula. This low also appears at higher levels, as shown in Figure 4. It is a winter situation involving severe weather with intense rain and strong south-westerly winds.

In the second type of situation there is zonal flow at the surface and higher levels, as shown in Figure 5. The jet stream plays an important role in this system.

The third type is a typical summer situation, and was found for three cases. At the surface there is a thermal low at the centre of the Iberian Peninsula whilst at upper levels there is a low over the country as shown in Figure 6. In this situation a mesoscale convective system develops which provides favourable conditions for tornadic developments.

CONCLUSION

This research has resulted in a database of some of the tornadoes and waterspouts that have happened in Portugal since 1936. Whilst the effects of most of these occurrences have not been important, some were of a strong intensity with occasional loss of life and property and a substantial number of injuries.

Much of the research was based on the memories of the public, though important data on some events could not be recollected. Weak tornadoes are under reported because they do not show remarkable effects.

Most of the events occurred in severe winter weather situations when a cold front, or a severe line squall, crossed the country in association with a deep low to the west of the Iberian Peninsula.

To understand the phenomena of tornadoes it is necessary to research every possible event. Just after a tornadic event has occurred the locality should be visited by authorised personnel to do a damage survey (Bunting and Smith, 1993). An expert study on the path, the effects and the eyewitness information give important clues to determine the characteristics of the storm.

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Year	1936	1954	1987	1988	1989	1991	1993
Event	1	1	3	1	3	1	1

Year	1994	1995	1996	1997	1999	2001	2002

Table 1: Year analysis of 25 events.

Table 2: Path analysis of 11 events.

Length (Km)	Width (m)	Intensity
> 11	100	T 6
> 9		T 7
5 - 6		T 4
> 5	50	T 4
4 - 5	50 - 100	T 4
4 - 5	200	T 4
> 4		T 4
3 - 4	50	T 5
3 - 4	30 - 50	T 4
> 3		T 5
> 2		T 3
	100	T 2
	200 - 300	T 5
	150	T 4
2		T 2 /T 3
0,3		T 1

Figure 1: Tornado at Portugal, Vila do Conde, April 21st 1999.

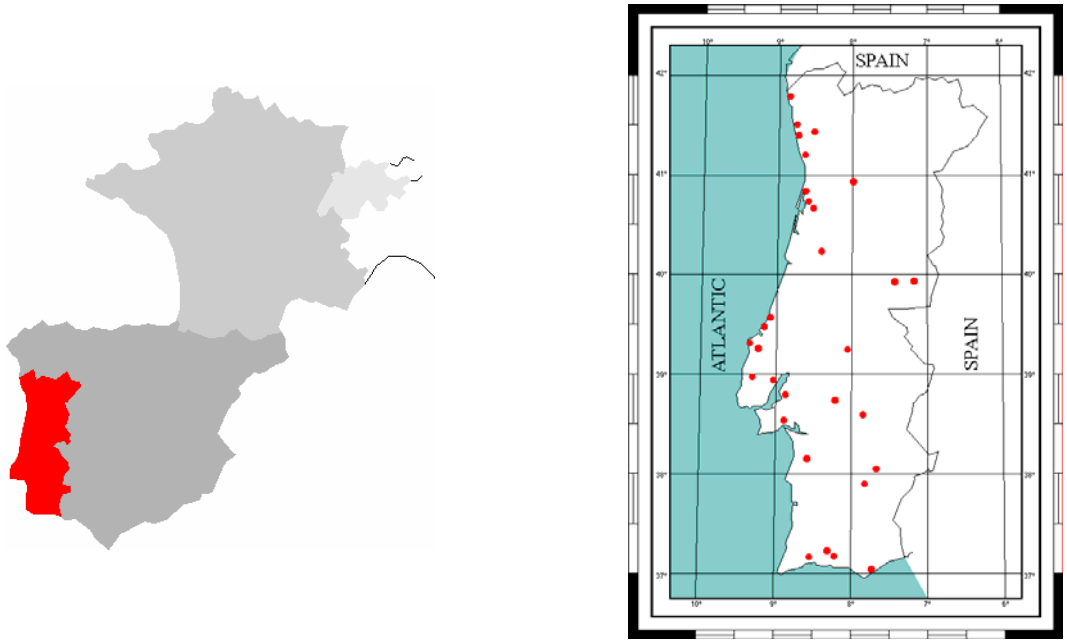

Figure 2: Location of the 30 events.

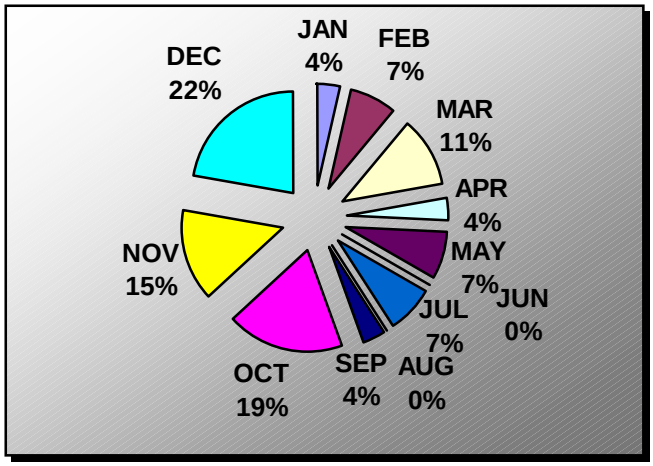

Figure 3: Monthly analysis of 27 events.

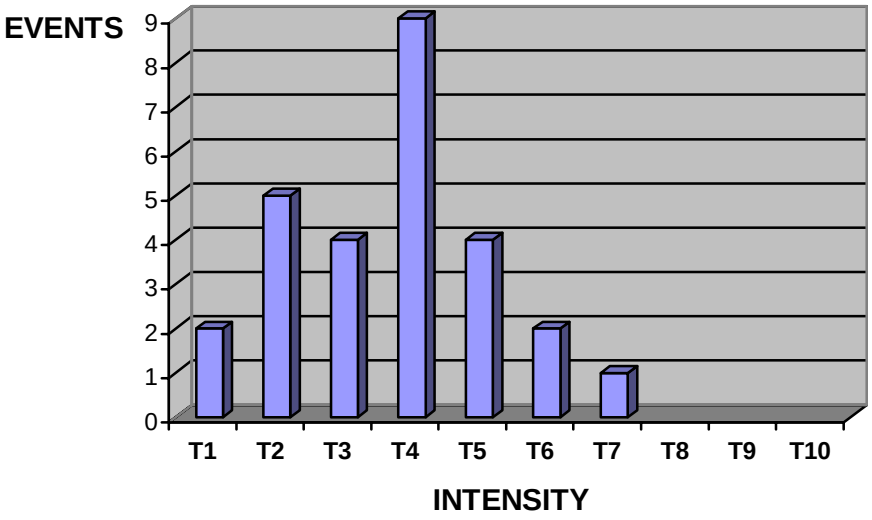

Figure 4: Intensity analysis of 27 events.

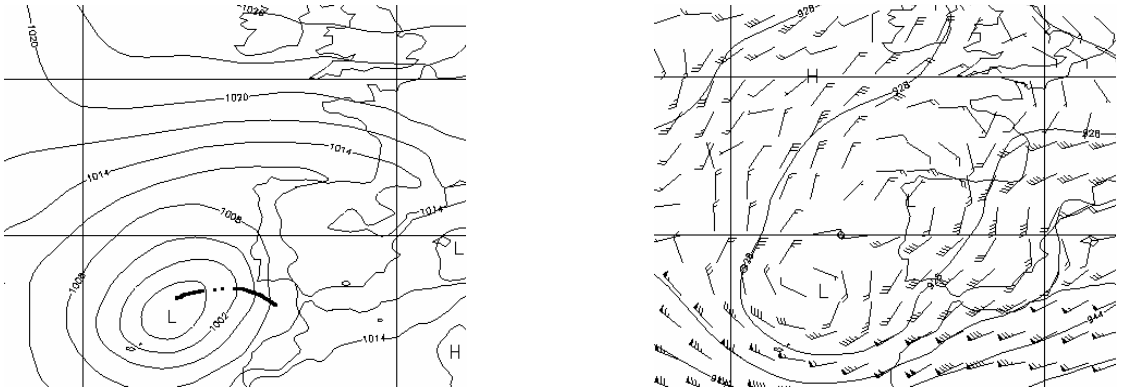

Figure 5: Weather situation on 31.10.1993 12UTC. At 16h40 a T5 tornado occurred in the south of the country, near the coast.
a) Surface map b) 300 hPa map.

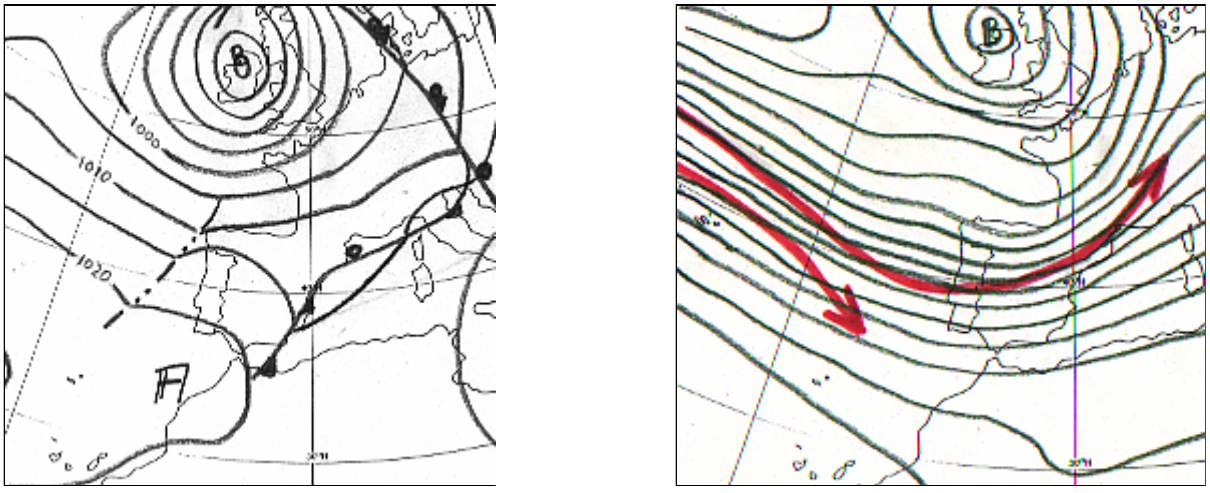

Figure 6: Weather situation on 21.04.1999 12UTC. At 11UTC a waterspout became a T4 tornado in the north of the country.
a) Surface map b) 300 hPa map and jet axis.

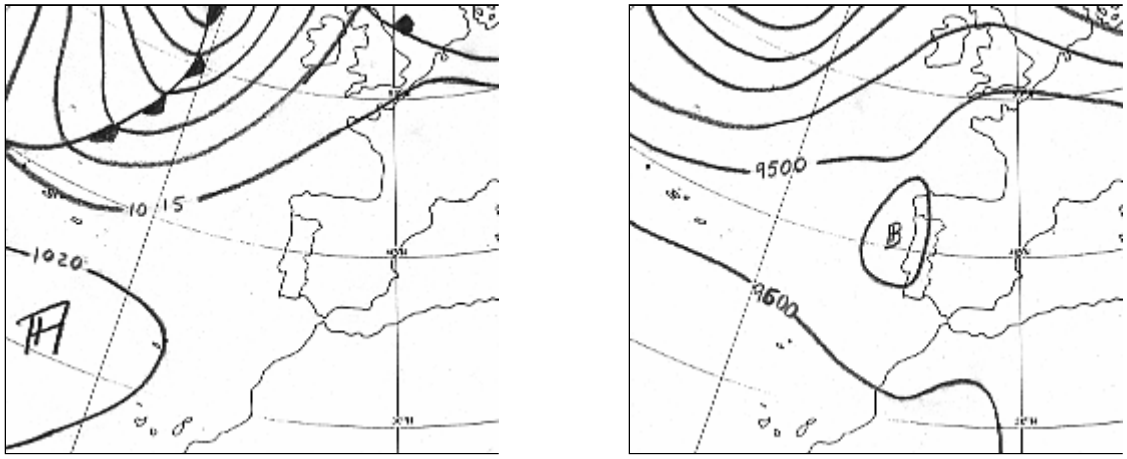

Figure 7: Weather situation on 20.09.1987 12UTC. A tornado occurred at Alentejo, in the south of the country.
Surface map b) 300 hPa map.