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Catastrophic Fire Behaviour in the June 2017 Pedrógão Grande Fire

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Abstract

Two fires that started near Pedrógão Grande in June 2017 were affected by the presence of a thunderstorm in the region and spread out of control as two initially separate fires. Sometime later these fires merged creating a very intense and fast spreading fire that threatened the lives of hundreds of persons. In a period of around two hours 66 persons were killed by the fire most of them trying to run away in their cars. The physical processes of fires start, interaction with the thunderstorm and merging were studied in detail as well as the circumstances in which the accidents occurred.

1. Introduction

The fires that started in the early afternoon of the 17th June of 2017 near Pedrógão Grande (PG) will be remembered as the worse in record in Portugal as they destroyed around 45000hectares but above all because they caused the death on 66 persons. Several authors analyzed this fire and produced reports studying various aspects of this very complex event, namely Viegas *et al.* (2017), Guerreiro *et al.* (2017), San-Miguel-Ayanz, *et al.* (2020).

The interaction between the thunderstorm, organized as a mesoscale convective system (MCS), and the fire was extensively analyzed in Pinto *et al.* (2022) using weather stations, satellite and radar observation data. The present work complements the previous reference, as the very unusual conditions that resulted from that interaction and produced the catastrophic fire during the late evening of that day are described in detail.

2. Fire ignitions and Spread

The fire of PG occurred in the district of Leiria, in Central Portugal (Figure 1), in a period of drought with air temperatures above 40°C and very low relative humidity. The wind flow in the region was from NW and not very strong. A large MCS developed over central-western Iberian Peninsula and moved towards W-NW causing several fires due to lightning, but at 14.30h (all indicated times are local time which is UTC plus one hour), when the fire of PG started, the more active part of this system was still nearly 100 km far from it and electrical strikes were not registered in the area of the fire until 18.00h (IPMA, 2017).

The fire of PG was actually caused by two ignitions that occurred near Escalos Fundeiros (EF) at 14.30h and near Regadas (RE) at 15.40h (Figure 2). Both ignitions were caused by an electrical line that was touched by tree foliage agitated by the wind that passes by both places which are 3.2km apart.

As there were other fire ignitions in the operational area the firefighting resources were dispersed and were not capable of coping with the very difficult spread of the EF fire which started to spot and threaten houses in the village of EF. When the fire of RE was detected there were not forces to deploy there and the fire was left spreading practically on its own. Between 18.00h and 18.15h a down flow from the MSC, which was not yet over the region of the fire, forced the fire column to tilt towards SW, spreading flames in a wide area and making the control of the fire virtually impossible from that time on (Figure 3). The RE fire which was smaller at that

time started to spread also completely out of control, towards NW forming the right side of a large pincer that was now advancing like a curved fire front more than 20km long, threatening a roughly circular area of 10km diameter (cf. Figure 1).

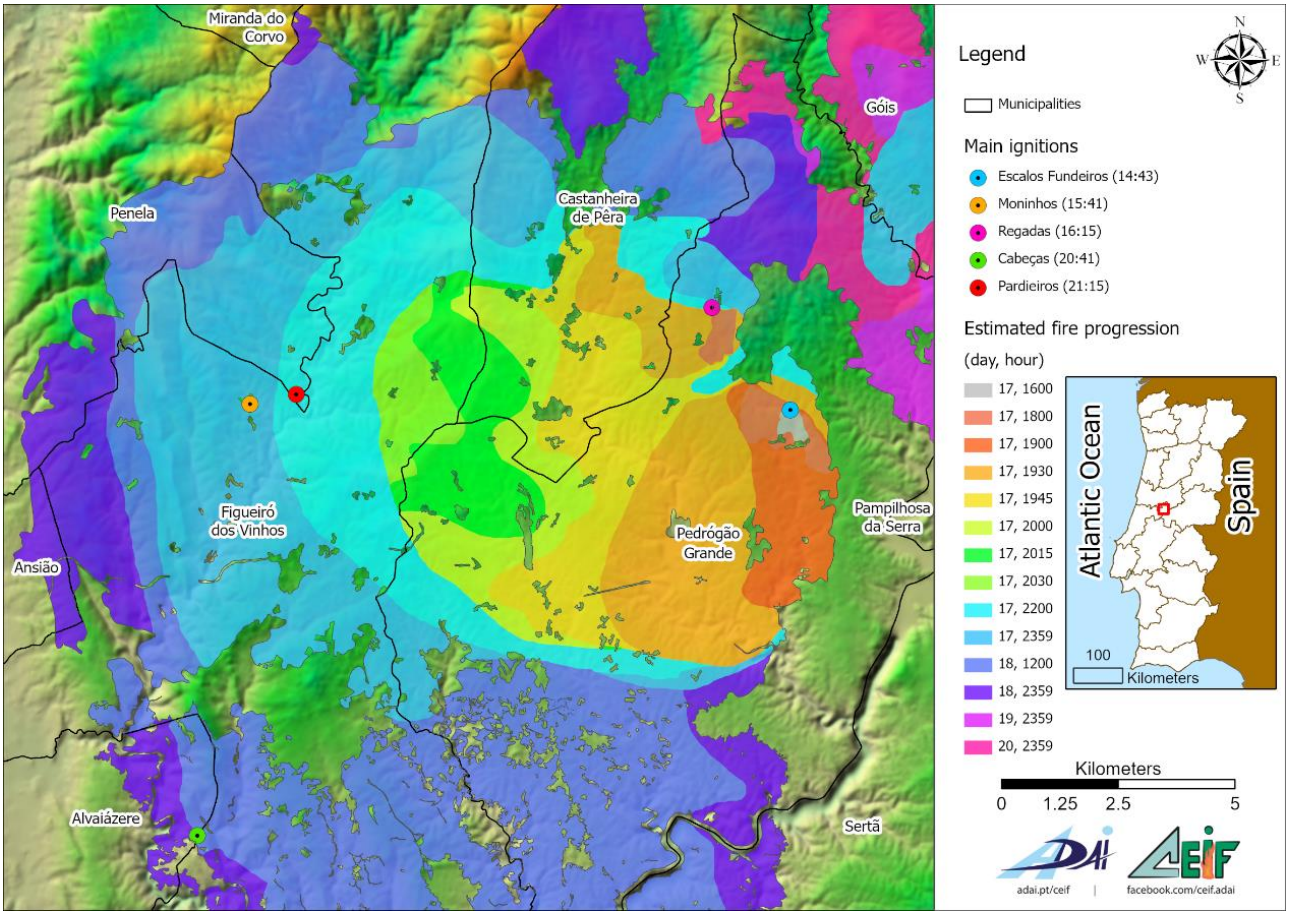

Figure 1 – Map of Portugal and of the area of the fire of Pedrógão Grande with the indication of fire ignition points and the fire spread.

a

b

Figure 2 – Aerial view of the location of the ignition points of (a) Escalos and (b) Regadas.

Figure 3 – Views of the column of the fire of Escalos Fundeiros at 18.00h and at 18.15h, showing the interaction with the down flow produced by the mesoscale convective flow.

3. Merging of the two fires

There is evidence that after 19.30h both fires had their inner flanks very close to each other making a small angle between them, therefore with the ideal conditions to merge as a junction fire that was studied by Raposo, 2012 and Viegas and Raposo 2018. Between 19.30 and 20.30h the process of merging induced very strong winds in the area ahead of the fire. The ROS of the head fire was of the order of 10 km/h. The quick combustion of a very large amount of vegetation produced a convection column that reached 12000 m at 20.10h and remained at that height for several hours. Flames of the order of 50m long and 50 to 100m long separated from the vegetation were registered, creating an environment near the ground like inside a furnace. There are reports of tree stands starting to burn from their tops to the ground (Figure 4). Persons in the area of the fire were under pitch dark and reported that the air was full of fire balls. Besides this there were pieces of wood, branches and bark flying all around, sometimes igniting new fires. In at least two much localized areas wind tornadoes twisted and broke a large number of 20cm diameter trees breaking them as toothpicks. The wind velocity required to cause this effect is estimated to be of the order of 200km/h.

Similar phenomena were observed in the process of merging of the McIntyre and Bendora fires near Canberra on the 18th January 2003, with a very fast spreading fire (27km/h) and a tornado that broke trees trunks larger than 30cm diameter (cf. Doogan (2006)).

The perception of the violence of the fire caused by the noise produced by its very tall and roaring flames, that threatened to destroy everything on their path, caused many citizens to decide to flee from their houses. Some of them took this decision in spite of knowing that their houses would normally sustain the passage of a fire, which most of them did. While running away in their cars many persons, sometimes entire families, were caught

by the smoke, loss of visibility and the flames and lost their lives. Particularly dramatic was the situation of a stretch of 200m of the Road N326-1, between Figueiró dos Vinhos and Castanheira de Pera (Figure 4), in which 30 persons were killed inside or near their cars.

Figure 4 – Some images of fire phenomena during its spread in the late afternoon of the 17th June.

The lack of maintenance of the vegetation - including trees – in the vicinity of the main roads contributed to the lack of survival conditions for the citizens. We identified one particular pine tree that was very close to the road edge and fell with the very strong fire induced wind over the road crossing it from one side to another. This tree and a group of cars that shocked with each other created a trap from which the cars could not drive out. Based on the testimony of survivors and of persons who passed by that road before or during the accident we were able to identify at least 16 persons whose death can be directly attributed to this tree.

The authors performed laboratory experiments at the Combustion Tunnel of the Forest Fire Research Laboratory of the University of Coimbra to simulate the development of the two ignition fires. Starting with the estimated perimeter of the fires at 19.30h with a flow of 2 m/s the merging of the two fires could be observed to follow very approximately the reconstruction that was made on the basis of testimonies and documented events during its spread. The isochrones of the fire spread are shown in Figure 5. It was also shown that the spread of a single fire (either EF or RE) would have been completely different if the other fire was not present, therefore confirming the relevance of the process of merging of the two fires.

The main fire was controlled on the 22nd June by 23.50h after consuming a total area of 45328ha, with the effort of more than 1400 fire fighters and other agents.

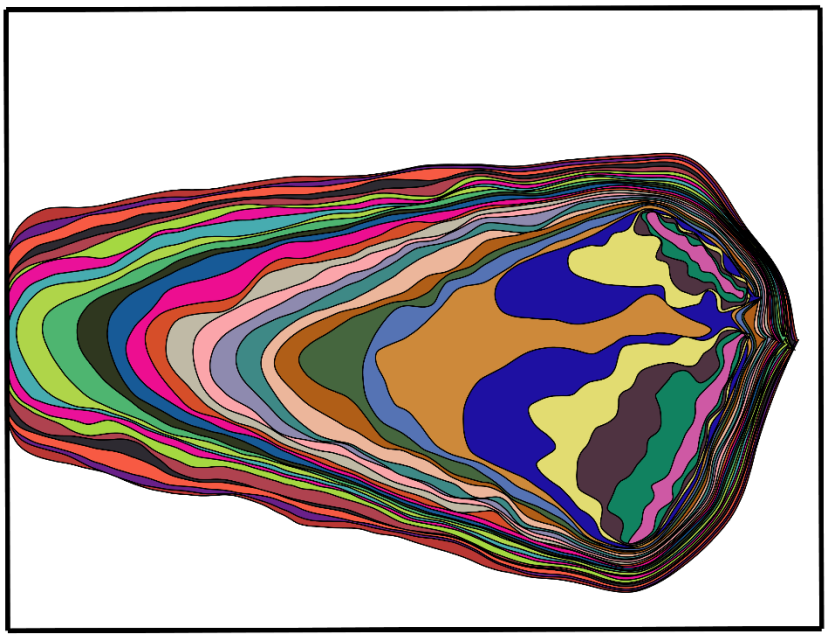

Figure 5 – Map with the isochrones of fire spread of the physical simulation of the two fires in the Combustion Tunnel of the University of Coimbra. The initial position of the fires (pink areas) corresponds at the situation at 19.30h. The time lapse between the lines is 20 seconds.

4. Conclusion

The fire that occurred on the 17th of June of 2017 near Pedrógão Grande covered and area of 45000 hectares resulted in the destruction of more than 1000 houses and structures and caused the death of 66 persons. It's very violent spread was caused by the fact that there were two separate ignitions that started 3km apart, caused by an electric line, and by the interaction of a down flow produced by a thunderstorm that was passing over the fire. The merging of the two fires produced very intense and unusual behaviour of the fire inducing many persons to escape from the fire in their cars.

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