FIRESTORM

PCIF/GFC/0109/2017

Numerical and experimental study of extreme fire behaviour processes: fire lines and fire whirls

ADAI and IDMEC

Workshop – 14 february of 2020

Associação para o Desenvolvimento da Aerodinâmica Industrial

IPMA Instituto Português do Mar e da Atmosfera

cesam universidade de aveiro centro de estudos do ambiente e do mar

idmec IST engenharia mecânica

FCT Fundação para a Ciência e a Tecnologia

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Project start:

01 february of 2019

Project end:

31 january of 2022

Keywords:

- Extreme fire behaviour;
- Meteorology;
- Atmosphere and fire coupling;
- Smoke emission and dispersion.

FireStorm

Weather and Behaviour of Fire Storms

Tasks:

- T3 - Conflagrations and mass fires;
- T4 - Merging of large fires;
- T6 - Modeling and practical guidelines.

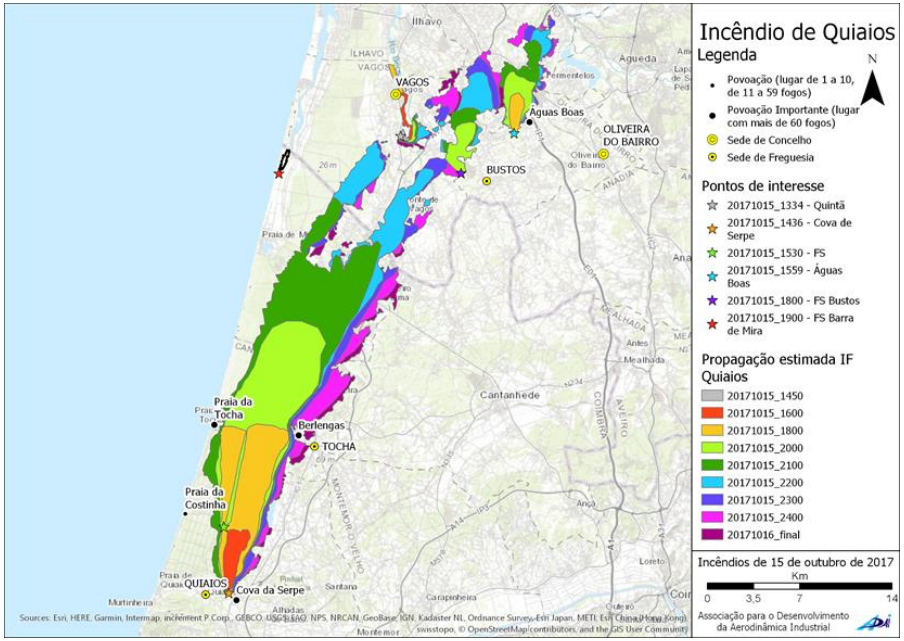
Objectives

- Analyze and model conflagrations and mass fires and some of the processes that are associated to them like crown fires, spot fires, and aerial flames;

- Analyze and model the merging of neighboring fires and the processes that are associated with them, such as fire lines, fire whirls and wind whirls;

- Disseminate the results of the project to the scientific and academic communities, the operational and political decision makers and also to the public.

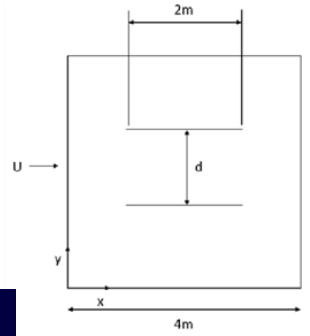
Extreme fire behaviour – Fire Lines
Real Situation – Quiaios, 15th October 2017

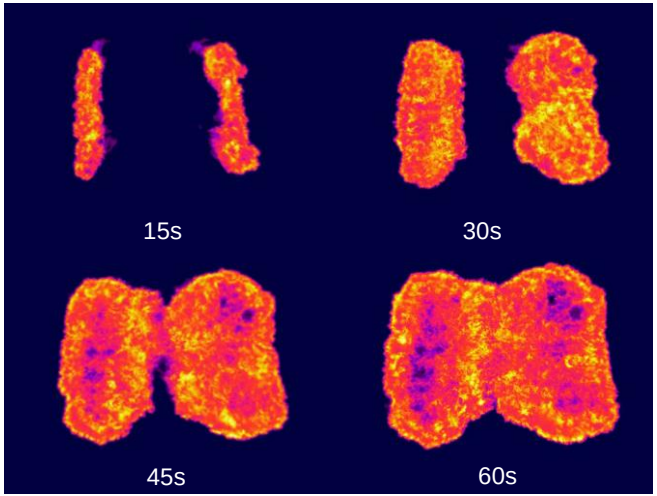


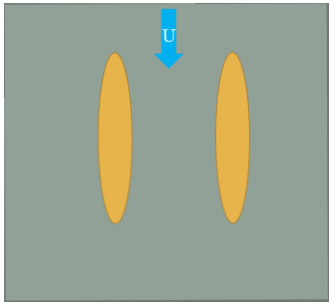
- By 3.30 p.m. when the fire started in Cova da Serpe it spread north, where a spot fire emerged;
- It developed in parallel, but was delayed relatively to the front of the original fire;
- The terrain in between the two parallel burning spots did not burn.

Extreme fire behaviour – Fire Lines Experimental Tests

- Study of merging of fire fronts and the processes that they generate;
- Results of experimental fire lines with IR camera and the result of visible camera;
- Tests with wind between the fire lines.

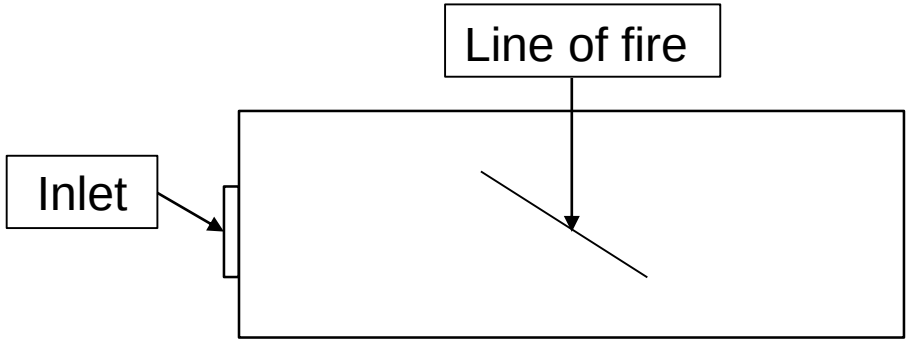


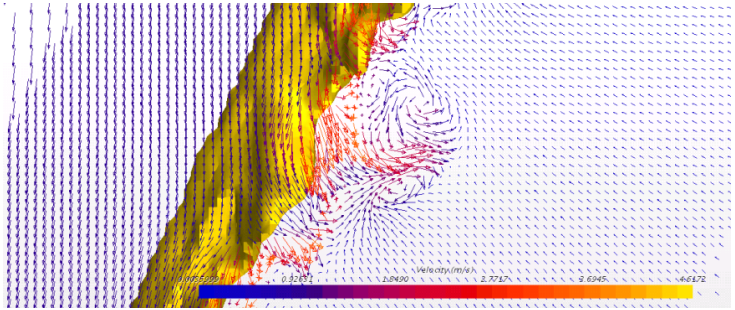




Extreme fire behaviour – Fire Lines Numerical Simulation

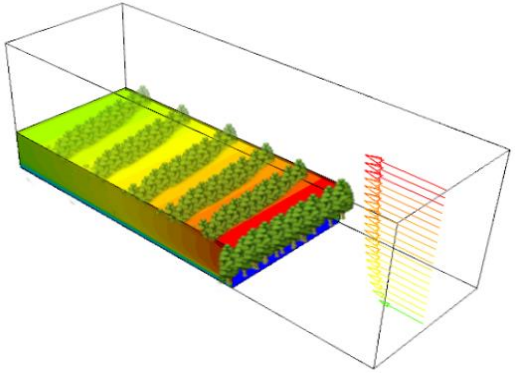
- 3D simulation of the interaction between a line of fire and non-perpendicular wind.
- Vortical structures have been identified in the near-flame region.

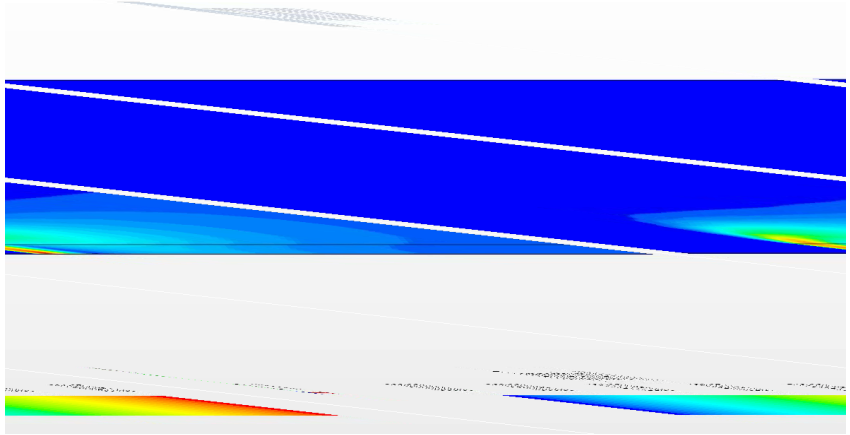




Extreme fire behaviour – Fire Lines Numerical Simulation

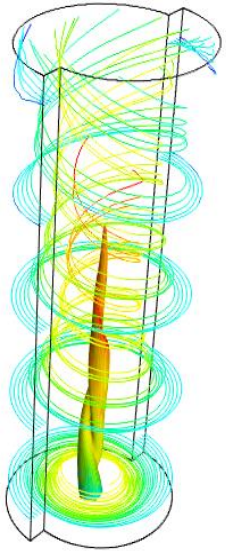
- 2D simulation of the propagation of a fire front under the effect of the wind.
- The forest is modelled as a porous medium.

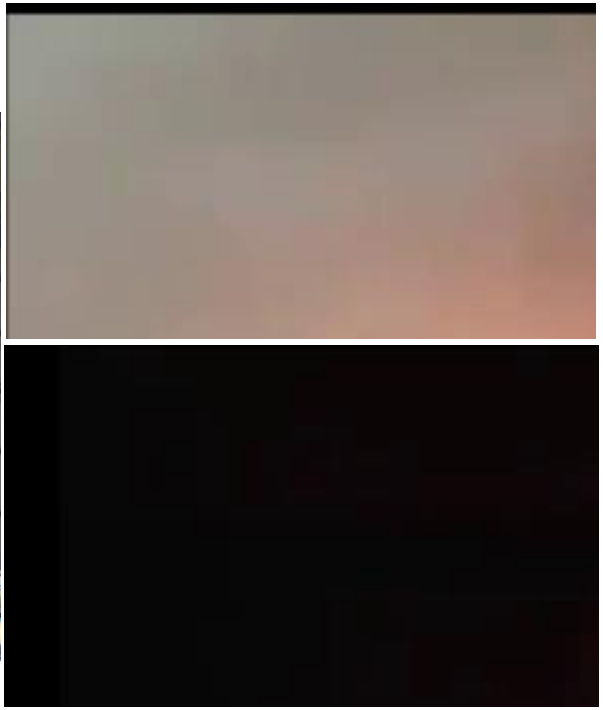




Extreme fire behaviour – Fire Whirls

- They are intense vortical flames.
- May result from interactions between the topography, fire and atmosphere.
- Their structure, properties and typical locations are mostly unexplained.





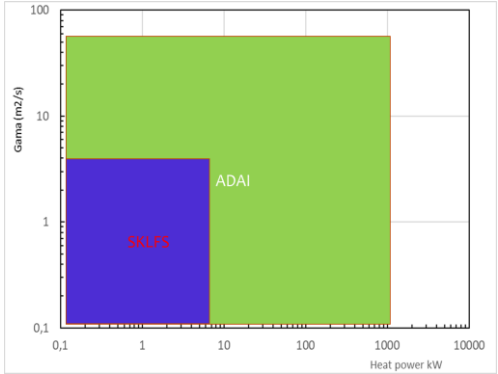
Arganil, October 2017

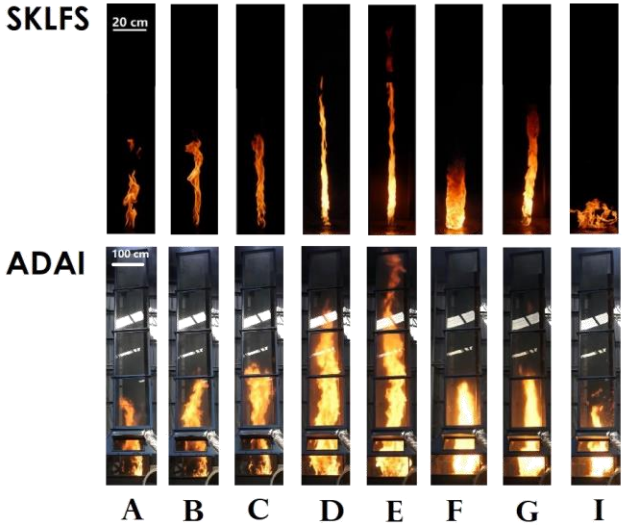
Extreme fire behaviour – Fire Whirls Experimental Tests

- Flame characteristics of a buoyant diffusion flame under imposed circulations.

- Nine flame patterns (small scale) were distinguished in theΓ-Q plot by SKLFS (Lei et all. 2017) – blue area in the plot.

- ADAI is increasing the study area to higher values of Γ and Q to a medium-high scale - green area in the plot.

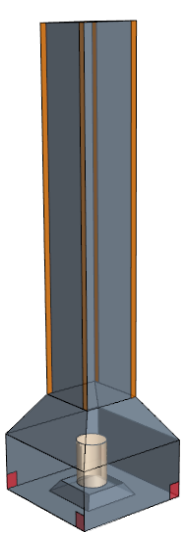


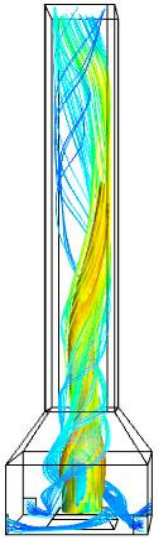


Extreme fire behaviour – Fire Whirls

- Experimental facility of ADAI simulated using CFD (constant heat release).

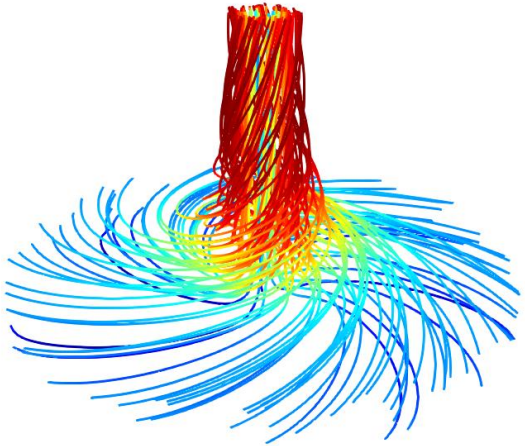
- Maximum flame height in the simulation is 6.115m VS 5.26m in the experimental work.

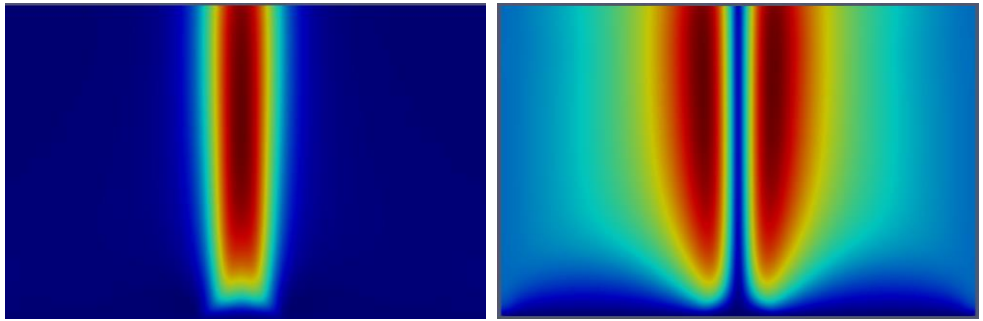


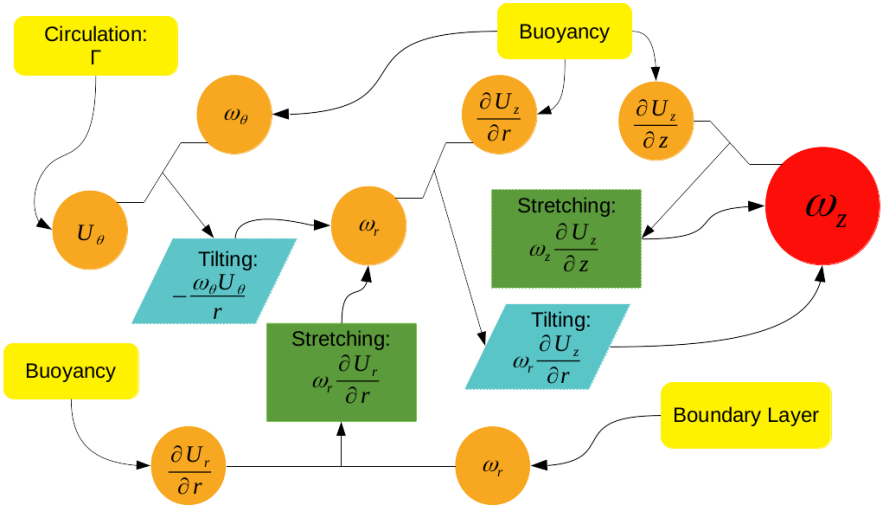


Extreme fire behaviour – Fire Whirls and their vorticity

- Why do fire whirls rotate? Why and under what conditions do they appear?
- 3D simulation of a whirling plume.







Conclusions

- Extreme fire behaviour, is a complex issue, due to its chaotic nature.
- It must be scientifically analyzed, in order to find ways to fight it more effectively and safely.
- Numerical and experimental methods can be used in conjunction to study these events in a more thorough fashion.

Future work

- Further analyze extreme fire behaviours in cooperation, including crown fires, spot fires, firewhirls, and aerial flames.
- Provide more information on the merging of fires.
- Find guidelines for improved ways of fighting and managing extreme fire behaviours.

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Extreme fire behaviour – Fire Lines

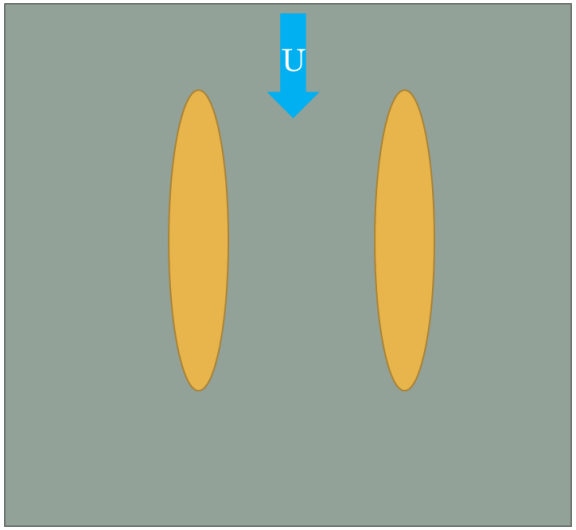
Fires that would have a natural tendency to interact with each other, do not do so in the same way when there is wind between them.

Deal with the problem of a linear fire front approaching a large surface in fire, using experimental and numerical simulation.

It will be considered the role of slope and wind at least partially for a set of configurations of the linear fire and of the shape of the surface in fire.

In the case of no slope and no wind, we will analyze:

- the effect of the intensity of the fire line;
- the size and intensity of the surface fire as well as of the initial distance between them.



Extreme fire behaviour – Fire Whirls

- Understand the processes of interaction between fire, topography and atmosphere that contribute to the formation of fire vortices in forest fires;
- The location, structure, properties and trajectories of the whirls will be studied and models to predict them will be proposed given their great destructive potential.

- The vorticity created by the flows around the fire induce the production of frequent and sometimes very intense whirlwinds and fire whirls;
- For the formation of a fire whirl, a heat source is needed, which in the case of the fire whirl is the fire itself and a flow that, when passing through the hot source, is disturbed, gains a tangential component and begins to rotate