Wildfires physics and modelling

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ABSTRACT

The behavior of wildfires is governing by various physical mechanisms, at different scales in space (and time), ranged between less than $1mm$ (the flame) to larger than $100km$ (the plume). Many of these physical mechanisms, such as the decomposition of the vegetation into combustible gas and solid, the chemical reaction inside the flame and its interaction with the atmosphere, are nonlinear, which constitutes an additional difficulty for their predictions using numerical models. For all these reasons, the numerical simulation of wildfires is a high challenging multiscale problem. Despite these difficulties, the resolution of some problems in fire safety engineering such as the propagation of a fire front through a wildland urban interface (WUI), needs to describe a fire at a relative local scale (few hundred meters), with a relatively high level of details. It is in this context, that a new class of fire models, referred in the literature as "fully physical models", has been proposed at the end of 90's [1, 2, 3, 4]. Before developing such kind of models, it is capital to identify all scales (in space and time) associated to the physical mechanisms contributing to the ignition and the propagation of a fire through a vegetation stratum.

To avoid the complete description of the vegetation, impossible task if we consider the fractal nature of the interface between all the elements (leaves twigs ...) constituting a plant, it is represented as an equivalent porous media, characterized by a set of local physical properties such as the density, the volume fraction, the composition. Then the problem is formulated from the balance equations (mass, momentum, energy ...) of the coupled system formed by the vegetation and the surrounding atmosphere. This approach is often referred in the literature as a multiphase formulation.

The objective of this lecture, will be to identify all the physical phenomenon and the associated scales, contributing to the dynamics of a forest fire, followed by a short presentation of what is a fully physical wildfires model and a presentation of some results obtained with this kind of approach.

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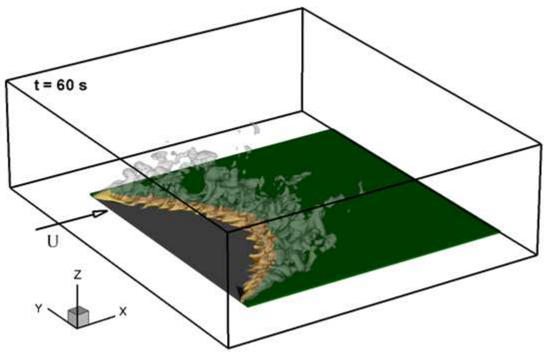

Figure 1: Example of numerical simulation of a surface fire propagating in a grassland (from Frangieh et al Fire Safety Journal 2018, in press)