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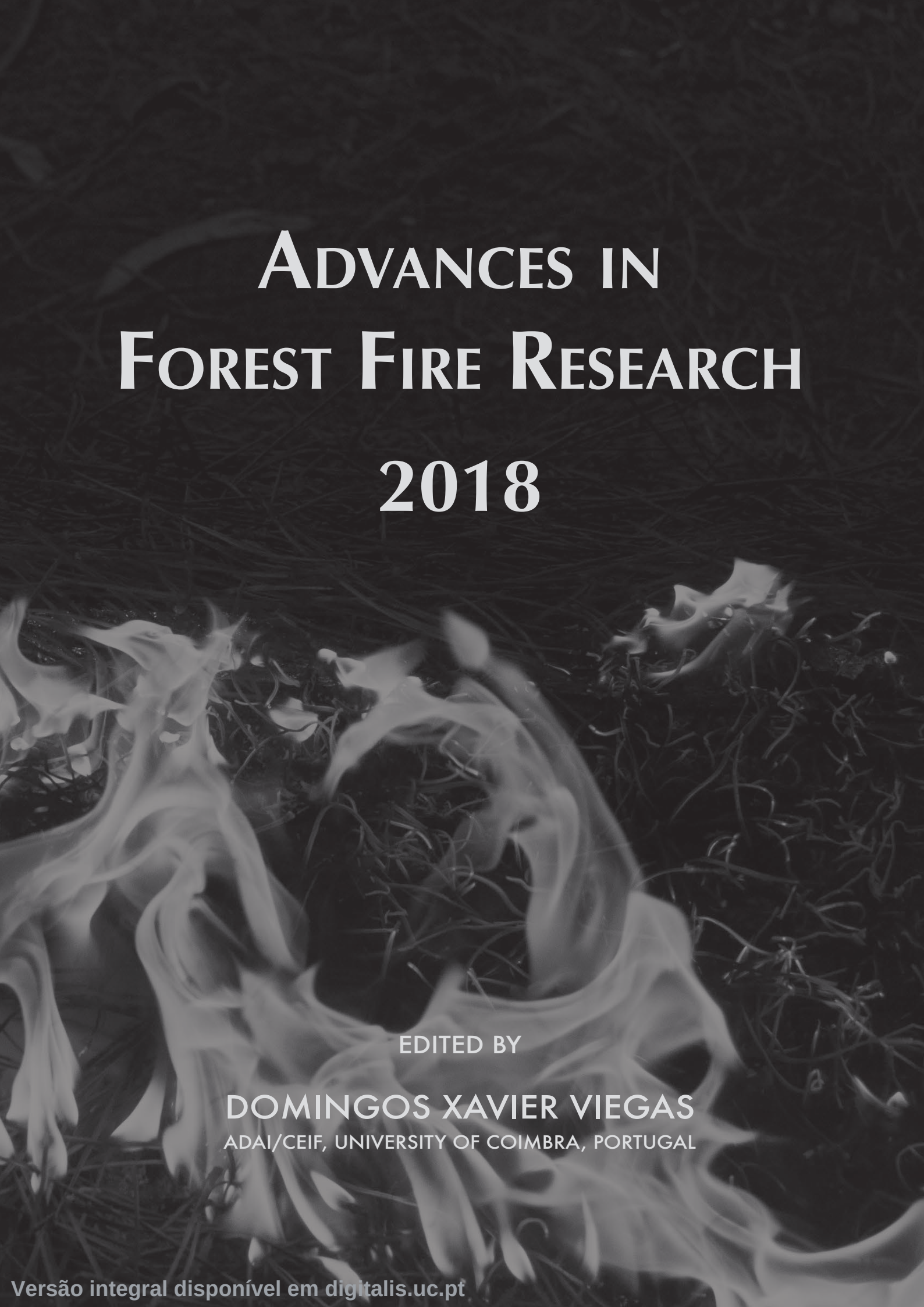

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On the use of time-resolved three-dimensional diagnostics to characterize firebrand showers in the WUI

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Abstract
A time-resolved, three-dimensional particle tracking and sizing diagnostic (a.k.a "emberometer") is currently being developed. It will be applied to airborne firebrands during wildland-urban interface fires; quantification of firebrand exposures would greatly improve the technical basis for WUI building codes and standards to address ignition vulnerabilities. The present paper provides an overview of the current system and reports test results demonstrating the ability of the system to characterize fluxes of artificially generated airborne firebrands.

Keywords: Firebrand; Wildland-Urban Interface (WUI); 3D Particle Tracking Velocimetry (3D-PTV); 3D Particle Shape Reconstruction (3D-PSR); firebrand flux; ember flux.

1. Introduction

Firebrands generated from burning wildland and structural fuels are known to be lofted into the air and transported up to thousands of meters from the active fire front (Koo *et al.* 2010). These firebrands can cause spot-fire ignitions of wildland fuels, as well as ignitions of structures built in the Wildland-Urban Interface (WUI) (Maranghides and Mell 2009). Existing WUI-related codes and standards (e.g., NFPA 1144, California Building Code Chapter 7A) lack the research support needed to sufficiently address ignition vulnerabilities in the WUI. A detailed characterization of the exposure from firebrands impacting the WUI (e.g., number/mass flux, particle size distribution, particle temperature, etc.) will provide a more complete definition of the WUI fire hazard (Maranghides and Mell 2013), and the technical basis for further improvements to WUI standards. While conventional measurement techniques have essentially focused on time- and space-averaged post-fire data (El Houssami *et al.* 2016; Filkov *et al.* 2017; Thomas *et al.* 2017), very little is known during an actual firebrand assault. The present work is devoted to the development and validation of a time-resolved, three-dimensional (3D) particle tracking and sizing diagnostic applied to airborne firebrands. Among others, the diagnostic intends to resolve Lagrangian trajectories and speeds of firebrands, as well as reconstruct firebrand shapes in 3D from which characteristic dimensions are extracted.

2. Experiment

2.1. Diagnostic description

In this work, the motion and size of airborne firebrands are resolved using 3D optical techniques. Firebrand motion is studied via 3D Particle Tracking Velocimetry (3D-PTV) which allows for the time-resolved mapping of individual firebrand trajectories. 3D Particle Shape Reconstruction (3D-PSR), following the principles of the visual hull concept (Laurentini 1994), is performed at each time step to yield firebrand characteristic dimensions. The following sections provide an overview of the system being developed as well as succinctly describe core steps involved in each technique.

All uncertainties are reported as expanded uncertainties, $X \pm k\, u_c$, from a combined standard uncertainty (estimated standard deviation) u_c, and a coverage factor $k = 2$ (95% confidence level,